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SHANGHAI*

John E. Orchard
School of Business, Columbia University

FIG. 1—A salt junk headed up the Yangtze Kiang.

Shanghai holds the commercial, financial, and industrial leadership of China. There is no rival, and none is likely to arise in the near future. In few countries of the world is there a city occupying a position of such relative national supremacy in the economic activities that are capable of record and measurement. China, it is true, is predominantly agricultural, with most of the people dependent for all their needs directly on the land and on the local village market and only remotely on any urban area; disintegration and disorganization seem to be more characteristic than centralization, but foreign and interport trade, banking and modern manufacturing for the entire country are focused on Shanghai to a remarkable degree, owing to an unusual combination of political and geographical factors. The control of Shanghai carries with it the control of the valley of the Yangtze Kiang, including one-half of the area of China proper and more than one-half of the population, the most productive agricultural areas, and most of China's large-scale manufacturing.

The Economic Importance of Shanghai

Among the cities of China, Shanghai ranks first in population with 3.4 million people, or more than double the number in Peiping, the

*This article is a part of a study of the industrialization of the Far East being made under the auspices of the Council for Research in the Social Sciences of Columbia University. The Japanese section of the study has been published in the volume "Japan's Economic Position," New York, 1930, and in several articles, including "The Pressure of Population in Japan," *Geogr. Rev.*, Vol. 18, 1928, pp. 374–401, and "Can Japan Develop Industrially?" *ibid.*, Vol. 19, 1929, pp. 177–200. The present article is based on data obtained in Asia in 1926–1927 and 1931–1932 supplemented by reference to available published material. In 1931–1932 the author traveled in China as a fellow of the John Simon Guggenheim Memorial Foundation.

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city of second importance. Primarily, Shanghai functions as a commercial city. It is China's principal point of contact with the world and the port through which much of China's recorded domestic trade flows. In the five-year period 1927–1931, 43 per cent of China's foreign trade passed through Shanghai. Dairen, the port of second importance and the outlet of Manchuria, handled 14.5 per cent, Tientsin less than 9 per cent, and Canton a little more than 5 per cent. With the loss of Manchuria and the elimination of Manchurian ports from the Chinese trade returns, Shanghai has become even more important relatively: for the two years 1933 and 1934 it handled on an average 54 per cent of the total foreign trade of China, and Tientsin, now the port of second importance, handled less than 11 per cent.[1]

The bulk of Chinese domestic trade is unrecorded. Many of the commodities are transported over short distances by boats, carts, or porters to be exchanged at some roadside or village market. Only the trade that passes through the recognized customs ports is measured. Of such trade in the five years 1927–1931 Shanghai handled 34 per cent; in 1933 and 1934, with the Manchurian ports excluded, the share increased to 36 per cent.[2]

Finance and Banking

In finance and banking Shanghai occupies a similarly commanding position. There were in the city in 1931, mainly in the International or Foreign Settlement and in the French Concession, 27 branches of foreign banks, 39 Chinese banks of modern type, either head offices or branches, and 77 native Chinese banks of the old type. These banks hold in their vaults huge stocks of silver attracted to Shanghai by the security offered by the areas under foreign control. In the last decade the reserves of silver have increased steadily, owing to the civil wars and the bandits of the interior. In 1927 the average stocks held were a little more than 150 million dollars, Chinese currency, and in 1934 the average had increased to more than 539 million.[3] In recent months the reserves have been seriously depleted by the shipments abroad that have followed the efforts of the American Treasury to raise the price of silver.[4]

The accumulation of the stocks of silver has caused a local building boom and the expansion of industry, but a more far-reaching effect has been the development of a system of credit that has extended over much of China and has financed a large part of the foreign and domes-

[1] *Foreign Trade of China*, 1927–1931, *The Trade of China*, 1932–1934 inclusive (continuation of *Foreign Trade*), China, The Maritime Customs (I.—Statistical Ser.: Nos. 3 to 5 and No. 1 respectively), Shanghai.

[2] *Ibid.*

[3] Prices and Price Indexes in Shanghai, National Tariff Commission, China, Shanghai, December, 1934, p. 23.

[4] See Professor F. W. Fetter's paper on "China and the Flow of Silver" in the present number of the *Review*.

tic trade of the country. Many of the banks in other treaty ports are dependent mainly on Shanghai for their operating funds, and Shanghai is the center through which accounts between North and South China are settled.[5]

The silver stored in Shanghai has served as a reserve against which bank notes have been issued. Owing to the security of Shanghai, such notes circulate much more widely than the notes of any other Chinese center, where there is always the danger of the seizure of the metallic reserves—when they exist—by bandits or war lords or by the government itself. Shanghai bank notes are China's nearest approach to a national currency. In 1931 the total issue amounted to some 290 million dollars (Shanghai). The notes circulated throughout the provinces of Kiangsu, Chekiang, Anhwei, Fukien, and Kiangsi. They were accepted as far north as Tsinan in Shantung Province, as far west as Ichang on the Yangtze, and down the coast to the extreme south.[6]

Manufacturing

Although statistics are not available for accurate measurement, it is certain that there has been much more advance in the development of modern manufacturing industry in Shanghai than in any other city of China, or in any other two cities. It is probable that Shanghai is almost as important in modern manufacturing as all the rest of China proper. The fairly adequate data on individual factory industries may be taken as evidence of the relative standing of the city. Of the 133 cotton spinning and weaving mills in China proper, Shanghai has 61 with 55 per cent of the total spindles and 57 per cent of the looms.[7] In the flour-milling industry, Shanghai has 15 of the 91 modern flour mills of the country with 47 per cent of the producing capacity.[8] Shanghai's position in the industries carried on in smaller establishments, such as silk reeling, matchmaking, knitting, and rubber manufacture, is equally important, and there are a great variety of industries still in the handicraft stage. Shanghai as a manufacturing center will be discussed more fully in later paragraphs.

The Origins and Growth of Shanghai

Unlike Yokohama and Kobe, the two great ports of Japan, which attained importance only with the opening of Japan to world trade, Shanghai was the leading commercial center of China long before the coming of the foreigner. The settlement apparently began as a fish-

[5] Richard Feetham: Report . . . to the Shanghai Municipal Council, Vol. I, Shanghai, 1931, pp. 303–304.

[6] *Ibid.*

[7] Complete List of Cotton Mills in China, Chinese Millowners Association, Shanghai, 1933. (In Chinese.)

[8] *Chinese Econ. Bull.*, Vol. 25, 1934, pp. 165–166.

ing village, and its ancient name of Hu Tu indicates an estuary where rows of bamboo stakes, fastened together with cords, are placed to catch the fish borne in by the tides. In the books of the Chin dynasty (300 A.D.) there is a reference to the repair of the mud forts thrown up at some earlier date about three miles to the north of the present city to protect the fishing estuary from pirate raids.[9] The first written reference to the name Shanghai seems to have been made in the eleventh century, when Shanghai was already important commercially.[10] The name may have a variety of translations—"up from the sea," "upper sea," "above the sea," or when written "Haishang," as it has been sometimes, "on the sea." Whatever the exact translation, there is no doubt that Shanghai, ancient or modern, is the product of the sea. In the sixteenth century, because of the attacks of Japanese pirates, fortifications were built and Shanghai became a walled town.

Arrival of the Foreigner

In view of the antiquity of Shanghai and its early importance in the domestic trade of China, it is amazing that contact with western Europeans was delayed to so late a date. The first western-European ship to reach Shanghai was the *Lord Amherst*, sent northward from Canton in 1832 by the East India Company. It entered the Yangtze almost two centuries after the arrival of the first British ships in Canton and three centuries after the Portuguese had reached Macao.

The Chinese officials received the mission from the *Lord Amherst* but informed its members that all trade must be through Canton. Another British ship, the *Huron*, visited Shanghai in 1835. The effort to open Shanghai, however, was dropped for several years. In 1842, during the Opium War, the city was captured by British troops, and in 1843 it was formally opened as a treaty port under the Treaty of Nanking, concluded in the previous year, which also provided for the opening of Amoy, Foochow, and Ningpo.

The long delay in the opening of Shanghai to foreign trade was undoubtedly due in part to the attitude of the Chinese officials. From the earliest times, even in the eighth and ninth centuries, when trade with the Arabs and the people of the South Seas had been encouraged, it had been the policy of the government to limit the contact to certain designated ports and thus minimize the dangers of penetration by foreigners. With the arrival of the western Europeans the policy had been continued, and the traders had been instructed to confine their activities to Canton. But it is likely that such restrictions would have been broken down by force much earlier, as they were eventually, if Canton had not been a convenient port. The European traders

[9] W. H. Medhurst: General Description of Shanghae and Its Environs, Extracted from Native Authorities, *Chinese Miscellany*, No. 4, Shanghai, 1850, pp. 34–35.

[10] *Ibid.*, p. 17.

arrived from the south by way of the Cape of Good Hope and the Indian Ocean. Canton was the southernmost trading port of China. To reach Shanghai it would have been necessary to sail northward another 850 miles along a coast uncharted at that time and dangerous even in the present day. The Europeans were content for a long period to have the Chinese traders assemble Chinese products in Canton. Through the sixteenth century at least, the Dutch carried on their trade with China by means of Chinese junks linking their colony in Java with the Chinese ports. They held that such a method was cheaper than direct trade and that it did not expose their merchants to the exactions suffered by other foreigners.[11] Only on the several occasions when the monopolistic tendencies of the Co-hong, the guild of Chinese merchants that controlled trade with the foreigners at Canton, became too restricting was there the threat to leave Canton for Amoy, Swatow, or Ningpo.

There was also little incentive to open up new trading areas, since there was only a small demand for Western manufactures. The Europeans paid for their outgoing cargoes in the earlier years mainly in silver and from the middle of the eighteenth century to an increasing extent in opium. Prohibited by the emperor Chia Ch'ing in 1800, the opium trade could probably be carried on illicitly with less interference at Canton than at some port nearer the imperial capital. So great did the inflow of the drug finally become that the staple exports of China, tea and raw silk, were not enough to balance it. About 1830 the movement of silver was reversed, and the metal began to flow out of the country to pay for the opium—an added reason for the opposition of the Chinese government to the import of opium. The efforts to suppress the opium trade at Canton led to war with the British in 1840 and to the opening of Shanghai and three other ports.

Early Commercial Development

The early visitors were greatly impressed by the importance of Shanghai. Gutzlaff, who visited the city in 1831 and again on the *Lord Amherst* in 1832, spoke of Shanghai as perhaps the principal commercial city of the empire.[12] The settlement was no longer a fishing village but one of the largest urban centers not only of the Far East but of the entire world. There are various estimates of the population, ranging from a total of 527,000 based on Chinese records of 1811 to the estimate of 270,000 made by Robert Fortune in 1843.[13] Gutzlaff

[11] *Decennial Reports*, 5th issue, 1922–1931, China, The Maritime Customs (I.—Statistical Ser.: No. 6), Shanghai, Vol. 1, p. 3.

[12] Charles Gutzlaff: Journal of a Residence in Siam, and of a Voyage along the Coast of China to Mantchou Tartary, *Chinese Repository*, Vol. 1, 1832–1833, pp. 16–25, 45–64, 81–99, 122–140, and 180–196; reference on pp. 124–125.

[13] Medhurst, *op. cit.*, pp. 107–110; Robert Fortune: Three Years' Wanderings in the Northern Provinces of China, 2nd edit., London, 1847, p. 104.

mentioned the numerous temples, the neat and comfortable houses, and the fact that the city was laid out in great taste.

At the time of the visit of the *Lord Amherst* in 1832, Mr. H. H. Lindsay, the supercargo of the ship, was most enthusiastic regarding the possibilities of Shanghai for trade.[14] In his report he described the commodious wharves and large warehouses that occupied the banks of the river, the fine harbor and anchorage, the accessibility of the port to the interior of China, and the magnitude of the junk trade. It was his opinion that the native trade of Shanghai greatly exceeded the trade of Canton, and he was so impressed by the number of junks in the harbor that he had the entries counted and found that in seven days some 400 junks ranging in size from 100 to 400 tons passed Woosung bound for Shanghai. If this record was characteristic of the entire year and not of the month of July alone, when Lindsay visited Shanghai, the city was one of the large ports of the world and compared favorably with London.[15] Unlike the trade of the great European ports of that day, that of Shanghai was almost entirely domestic, the junks coming from Tientsin, Manchuria, Fukien, Kwangtung, and Formosa, and, in relatively small numbers, from the South Seas, Cochinchina, and Siam.

Robert Fortune, a botanist from the Royal Horticultural Society's Garden at Chiswick, England, who visited Shanghai in 1843, described the "forest of masts" that met the eye on the trip up the river to the town. The early observers were apparently more interested in the junks than in what they carried, for there is little mention of the commodities entering into the trade. Grain, peas (probably soybeans), and medical drugs were brought from Manchuria, and tea, silk, and cotton cloth (nankeens) seem to have been the principal exports. Foreign manufactures had evidently been brought in from Canton long before the first Europeans reached Shanghai, for the supercargo of the *Lord Amherst* saw many articles, particularly foreign textiles, on sale in the shops.[16]

The Eclipse of Canton

Once the port of Shanghai had been opened, development was rapid. After the Treaty of Nanking there was a period of overexpansion, when foreign officials, merchants, and manufacturers, unfamiliar with the consuming habits of the market, were much too

[14] H. H. Lindsay and Charles Gutzlaff: Report of Proceedings on a Voyage to the Northern Ports of China, in the Ship Lord Amherst; Extracted from Papers by Order of the House of Commons Relating to the Trade with China, London, 1833, p. 209.

[15] There entered into the port of London, on the average, each week of the three-year period 1840–1842, in foreign and coastal trade, 558 vessels averaging 158 tons each (Tables of the Revenue, Population, Commerce, etc., of the United Kingdom and Its Dependencies, 1840–1842, Compiled from Official Returns, Presented to Both Houses of Parliament by Command of Her Majesty, London).

[16] Lindsay and Gutzlaff, *op. cit.*, pp. 172 and 181.

optimistic concerning the future of the China trade. Sir Henry Pottinger, the British plenipotentiary, is reported to have said publicly that the treaty had opened to trade a country so vast that all the mills of Lancashire could not make stocking stuff sufficient for one of its provinces,[17] a statement of a kind with the later famous remark of Wu Ting-fang regarding the additional inch on the shirt of the Chinese and the producing capacity of the cotton mills of the world. It soon became evident, however, that there was a real demand in the Shanghai area and in the Yangtze Valley for cotton cloth, particularly the plain goods, and that the port was admirably situated as an outlet for the products of China. It was much nearer the areas producing tea and silk, and these commodities, constituting as they did in 1842 more than 90 per cent of China's commodity exports,[18] could be assembled much more readily than they could in Canton. In 1843 Fortune had prophesied that Shanghai would soon surpass Canton in foreign trade. He returned to Shanghai for a second visit in 1848 and was again impressed by the forest of masts, but this time the native junks were overshadowed by the larger vessels, chiefly from England and America, twenty-six of which were at anchor in the harbor.[19]

Within a year after the formal opening of Shanghai no fewer than 11 foreign firms were established in the port, including the American firm Russell and Company and the British firm Jardine, Matheson and Company. The increase in the export trade was immediate. In 1845 Shanghai exported 6433 bales of raw silk. Eleven years later the quantity had reached more than 92,000 bales, a very large share of the Western demand. The export of tea from Shanghai increased from about one million pounds in 1844 to more than 80 million pounds in 1855.[20]

The rapidity with which Shanghai fulfilled Fortune's prophecy in the race with Canton was amazing. In 1842 Canton was still China's one point of contact with the West and enjoyed a virtual monopoly of the foreign trade. Exactly comparable data for these early years are not available, but it would seem that Canton still held the lead in 1851, though there was no question that a rival was arising. By 1863 the new port had established its supremacy, and eight years later, in 1871, Shanghai's share of the purely external trade of China, excluding the coastal trade, was 63 per cent of the total, and Canton's share only 13 per cent.[21]

Shanghai surpassed Canton, the old established port, mainly because of a better geographical location with access to a much more extensive hinterland, but partly because of the survival in Canton of

[17] *Decennial Reports* (*op. cit.*), Vol. 1, p. 39.
[18] *Ibid.*, p. 18.
[19] Robert Fortune: A Journey to the Tea Countries of China, London, 1852, p. 12.
[20] *Decennial Reports*, Vol. 1, pp. 26–27.
[21] *Ibid.*, pp. 32, 45, 59, and 74.

the old conservative and restricting methods of conducting trade. Canton trade with the foreigner had been through the Co-hong, and foreign merchants were not permitted to carry their business into the interior. Although the Chinese attempted to limit trade at Shanghai as it had been limited at Canton, their efforts were resisted vigorously and effectively by the foreigners. Shanghai opened with new methods and with much greater freedom to foreigners. They could send their Chinese agents into the interior to buy silk and tea, and they were not compelled to deal with any particular Chinese merchant. Although the Co-hong had been abolished by the Treaty of Nanking, and although it had been provided that British subjects should be permitted to deal with whomsoever they pleased, the treaty was in reality a dead letter for the first few years except at Shanghai. The people of Canton refused to allow foreigners within the walls of the city, and the merchants attempted to revive the Co-hong under the guise of licensed warehouses for tea. The officials made every effort to hold the trade in its old channels. The imperial government, in the hope of confining foreign trade as completely as possible to Canton and thus nullifying the opening of the new ports by the treaty, ruled in an imperial edict that on all raw silk, no matter to what port it was shipped, transit dues should be paid to the amount that would have been paid if the silk had gone to Canton. The edict had little effect, since the savings in transport charges and in loss of interest were so great on shipments to Shanghai that they much more than offset the added transit dues. By 1851 the Taiping Rebellion had so badly disrupted overland trade routes that Canton was cut off from all but its immediate hinterland. The wars with the British and French in 1856 and 1857 further interfered with Canton's trade and led to the removal of the headquarters of the remaining foreign merchants to Hong Kong.

With the opening of new ports under the terms of the Tientsin Treaties of 1858 and subsequent treaties a number of potential rivals to Shanghai were established. There are now 69 treaty ports, and 11 additional ports have been opened voluntarily by China. Shanghai, however, has remained the dominant port of the import trade. By 1881 it controlled about two-thirds of the total direct foreign imports into China. The imports were mainly manufactured goods and could be handled and marketed much more advantageously through the facilities of a large city. In the export trade the smaller ports could function. Raw silk and tea were not so completely the export commodities as they had been in 1842, but in 1881 they still constituted 84 per cent of the total. A considerable share of the raw silk went out from Canton, and tea was exported from Foochow, Hankow, and Canton, the ports near the areas of production. In the early years of the twentieth century (average for 1904–1908) Shanghai handled 51 per cent of the foreign trade of China and was slightly more important

relatively in imports than in exports. In more recent years, with the growth of a number of small ports, particularly along the Yangtze River, in North China, and in Manchuria, the relative importance of Shanghai has declined, though the trade of the city has shown an absolute increase. In the five-year period ending with 1931, as stated in an earlier paragraph, 43 per cent of China's foreign trade passed through Shanghai. The same tendency that developed after the Tientsin Treaties is still apparent: just half of the import trade, mainly manufactured goods, was taken by Shanghai, but Shanghai's share of the export trade amounted to only 35 per cent, the smaller ports continuing to handle the raw materials.

Advantages and Disadvantages of Shanghai

Political Security

A variety of factors have contributed to the rapid development of Shanghai and to its present preëminence in China. The growth of the port before the coming of the foreigner was due almost entirely to natural geographical advantages that are just as effective today as they were a century ago. To the political security enjoyed by Shanghai under the protection of foreign powers has been attributed much of the economic development since 1843. In its reply to the questionnaire of Justice Richard Feetham in 1930, the British Chamber of Commerce of Shanghai stated flatly that there were two main causes for the development of Shanghai, geographical position and security, and that of these two security was by far the more important.[22] Although such a statement undoubtedly overemphasizes the part played by political factors, they have been important. Security was a guiding motive of Sir Henry Pottinger in his selection of the site of the British Settlement in 1842 with the Whangpoo, a wide, navigable river, on the east and defensible creeks on the other sides.

From the beginning the authorities of the Settlement have insisted on its neutrality, not only in any internal conflicts in China but in any wars between a foreign power and China, and on the right to exclude Chinese armed forces. These two rights have been asserted repeatedly and not always with justice to the Chinese. The more serious occasions were during the Taiping Rebellion in 1853, the Boxer uprising in 1900, the revolution against the Manchus in 1911 and 1912, the successful advance northward of the Nationalist forces in 1926 and 1927, and the Japanese invasion of 1932. Although local volunteers and the foreign troops at hand have been used to enforce the neutrality of Shanghai, in the final analysis security has rested on the foreign naval vessels and the ease with which they can enter the Whangpoo and anchor off the Bund.

[22] Feetham, *op. cit.*, Vol. I, p. 268.

Security has encouraged the development of commerce and of manufacturing under foreign control. It has attracted surplus funds from the interior of China, and those funds have been invested in economic enterprises. It has provided a haven for wealthy Chinese, some

FIG. 2—Map of China (scale: 1 : 31,600,000) showing the central location of Shanghai on the coast and at the mouth of the great waterway system. The inset topographical map (1 : 84,000,000) emphasizes the high mountain and plateau barriers that focus the Yangtze valley on Shanghai.

of whom have been active in promoting economic development. Security alone, however, could not have made the Shanghai of the present day. If security had been the only factor, it would have been an advantage possessed equally by Tientsin, Hankow, and Canton and to an even greater degree by Hong Kong. Shanghai was a great trading center long before the foreigner brought in his security. The port would have continued to develop economically if the foreigner

had heeded the wishes of the Chinese and remained in Canton. Shanghai possesses a geographical position unequaled in China and surpassed by few other cities of the world, and it is upon that geographical position that the Shanghai of today has been built.

Larger Geographical Factors

Shanghai is almost midway between the north and south limits of the east coast of China. To the south, there are, in addition to Canton, numerous small ports, including Ningpo, Foochow, Amoy, and Swatow, among which the trade is divided. Their harbors are shallow or cramped, or their hinterlands are limited by mountains or by inadequate means of communication. No one of these ports is capable of becoming a rival to Shanghai, and at present most of their trade is coastwise, each depending on Hong Kong or Shanghai for foreign contacts. North of Shanghai the geological history of the coast has not been conducive to the formation of good harbors. With the exception of the mountainous stretches of the Shantung and Liaotung peninsulas, the coast has an emerging shore line constantly building seaward with the sediments deposited by the streams emptying into the Yellow Sea and the Po Hai. The river mouths are choked with silt and are wholly unsuitable for navigation by large ocean vessels.

Tientsin, the largest port of the northern part of China proper, is reached by a shallow channel that can be kept clear of silt only with difficulty.[23] The harbor, moreover, is liable to be closed by ice. Tsingtao has perhaps the finest harbor in all of China, but it is on a peninsula, and the important hinterland of North China is reached by only a single railway line running through Shantung Province to Tsinan. The ports of Chefoo, Newchwang, Dairen, and Chinwangtao may be dismissed as possible rivals of Shanghai, since by their location they can serve only northern Shantung, Manchuria, Mongolia, and the extreme northern part of Hopei Province. China, considering the length of the coast line, is singularly deficient in harbors, and in a sense Shanghai has attained its present supremacy by default, since there exists no worthy competitor and trade has been concentrated at one point. That concentration, however, has been increased by the excellence of Shanghai's position.

Location of Shanghai

Situated near the mouth of the Yangtze Kiang, China's principal river, Shanghai has access by water to a great delta and valley occupying the central part of the country. The area of the delta is 50,000 square miles and the total population some 40 million, or a density

[23] Margaret A. Hatch: The Port of Tientsin and its Problems, *Geogr. Rev.*, Vol. 25, 1935, pp. 367–381.

of about 800 to a square mile. In the entire Yangtze Valley there are 750,000 square miles, about one-half of the area of China proper, and nearly 180 million people, about one-tenth of the population of the world. No other port of the world has tributary to it so populous an area. Calcutta, at the mouth of the Ganges Valley, with a tributary

FIG. 3—A view of the Hankow bund taken from the Wuchang side of the river and showing the great width of the Yangtze 600 miles above Shanghai.

area of some 450,000 square miles and a population of 145 million, is probably the nearest rival.

Within the delta of the Yangtze there are numerous urban areas important in manufacturing of both the old handicraft and the modern factory types and dependent on Shanghai as a port. In the Tai Hu area are the two great cities, Soochow, the ancient handicraft center of the empire, with its silk weaving and luxury industries, and Wusih, a modern center surpassed only by Shanghai. To the south on the edge of the delta is Hangchow, another old city, which still retains some of the industries dating back to its period of glory as the capital of the Southern Sung. Along the Yangtze are Nantungchow, Chinkiang, Nanking, Kiukiang, Wuhu, and Hankow, and, above Hankow, Shasi, Ichang, and Chungking. The Yangtze is navigable to all these cities. Hankow, 600 miles above Shanghai, is accessible during the summer months by a channel of 28-30 feet for vessels of 8000, or even 10,000, tons, and during low water by a channel of 8-10 feet for vessels of 2000 tons. For 350 miles more to Ichang the Yangtze is navigable by river steamers, and for 360 miles farther to Chungking, during the summer months, by specially constructed high-powered and shallow-

draft vessels. Tributaries such as the Han River, which enters the Yangtze at Hankow, the Hsiang River and Tungting Lake, which join the main stream at Yochow, and the Kan River and Poyang Lake, which join at Kiukiang, add many more miles of major waterways navigable by small steamers and junks. Innumerable minor water-

FIG. 4—The waterfront at Hankow. The photograph was taken shortly after the flood of 1931 had receded, the effects of which are still visible on the river bank.

ways—streams and canals—cover the entire alluvial plain with a network and serve as feeders to the larger streams.

The traffic from the entire valley is drawn down the tributaries and down the Yangtze as in a funnel, and back along the same channels flow the foreign imports or the manufactures of the coastal cities. A comparatively small part of the trade of the valley crosses its land boundaries, since the valley, except in its lower reaches, is isolated from the rest of China by natural barriers strengthened by the absence of adequate communication on land. To the west are the highlands of Tibet, to the southwest the high plateau of Yunnan, to the south and southeast the southern tablelands, and to the north and northwest the Tsinling Shan and connecting ranges. With the exception of small trickles of trade that may pass overland through these barriers, the valley is and will remain essentially the hinterland of the estuary of the Yangtze and of its port, Shanghai.

The many advantages of New York City with reference to its hinterland are often cited as an illustration of the importance of geographical factors in the growth of a port. It would seem that Shanghai illustrates that importance even more strikingly. Its hinterland is

SHANGHAI AND VICINITY ABOUT 1010 A.D.

SHANGHAI AND VICINITY ABOUT 1850 A.D

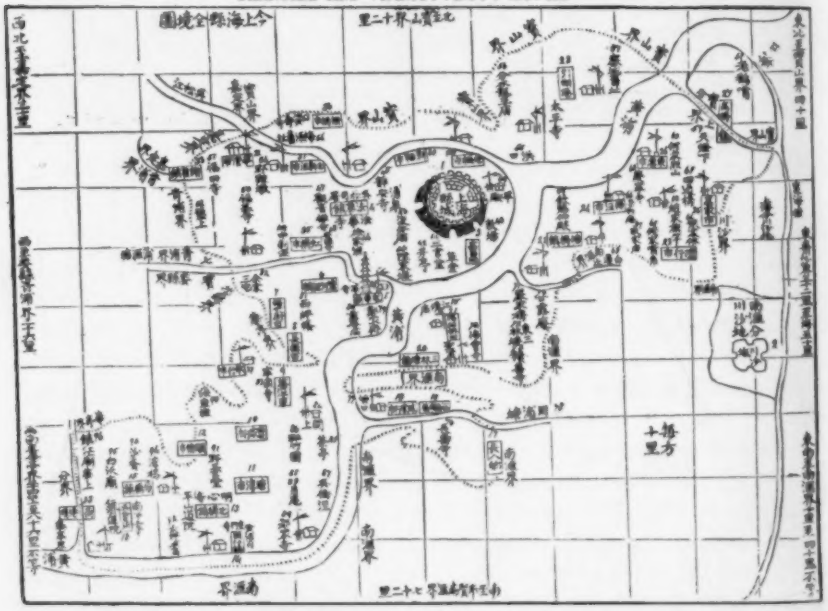

FIG. 5—Two maps of the Shanghai district showing the changes that have occurred in the character of the Whangpoo River and Soochow Creek. In the upper map (scale approximately 1 : 1,000,000) the large stream to the north is the Woosung River (Soochow Creek). It is joined by (2) the Whangpoo. No. 7 is Shanghai Town, 8 and 9 are forts, 24 is Tsinglung Town, 68 is the "Sea" (Hangchow Bay), and 69 is Hu Tu Marsh. On the lower map (scale: each square 10 li, or about $3\frac{1}{3}$ miles, on each side, i.e. approximately 1 : 570,000), No. 1 is Shanghai Walled City. The main stream is the Whangpoo, now much increased in size, and the stream to the north of the walled city is Woosung River (Soochow Creek), reduced to about its present size. The mouth of the Whangpoo is at the upper right-hand corner of the map. The two maps are reproduced in W. H. Medhurst: General Description of Shanghae and Its Environs, 1850, from the Ta Ch'ing I T'ung Chih (Annals of the Ch'ing Dynasty).

much more extensive than that of New York, and its tributary population is much greater. New York gained easy access to its hinterland only with the building of the Erie Canal and later of the railroads. At the present time the waterway is wholly inadequate and ineffective. Shanghai, on the other hand, possesses a natural entrance to the valley by water that will undoubtedly continue to be the main highway of trade.

Shanghai is not on the Yangtze but on a tributary, the Whangpoo, at a point some fourteen miles above its junction with the main stream. The great port of central China has developed there partly because the tributary affords more protection from typhoons than would any location in the wider mouth of the Yangtze. Of more importance, however, has been the greater freedom from silting. On the smaller Whangpoo dredging has been necessary, but there has been a much less serious problem in combating the lighter load of silt carried by the tributary stream. The Yangtze carries a tremendous load of silt and has been building the coast of China eastward at a rapid rate for centuries. The town of Quinsan, for example, was the seaport of the district some two thousand years ago. It is now 30 miles from the south bank of the Yangtze and 80 miles from the sea. Tsinglung, 20 miles above Shanghai on Soochow Creek, was made the seat of the customs office in 1101, but in 1347 the water had become so shallow that the office was removed to Shanghai.[24] In 780 the Whangpoo was only a bowshot wide and was truly a creek, as the suffix *poo* (or *p'u*) indicates. Soochow Creek, then known as the Woosung River, was probably five miles wide. Gradual silting and the shifting of deposits, to be expected in the delta of so large a stream as the Yangtze, narrowed Soochow Creek and widened the Whangpoo until by 1875 the creek had become only a few hundred feet wide and the Whangpoo more than half a mile.

In the early years after the opening of Shanghai to trade many foreigners expected that the focus of trade for central China would shift eventually to some port on the Yangtze such as Nanking, a former capital, or Chinkiang, which is at the point where the Grand Canal provides a waterway cutting the Yangtze at right angles and stretching northward to Peiping and southward to Hangchow. Chinkiang was opened to trade in 1860 and attained some importance as a collector of Chinese products and a distributor of foreign goods, but the task of keeping open a deep enough channel near the shore has been too formidable. The river is shifting northward at that point. Golden Island, where British men-of-war anchored in 1842, is several miles inland, and Chengjenchow Spit has grown into a mud bank completely blocking access to the landing stages along the British Concession and threatening those at the mouth of the Grand Canal.[25]

[24] Medhurst, *op. cit.*, pp. 6 and 17.

[25] *Decennial Reports* (see footnote 11), 1st issue, 1882–1891; 4th issue, 1912–1921; 5th issue, 1922–1931.

Nanking, opened to foreign trade in 1899, has not had the same difficulties with silting, but the port did not have adequate means of communication with a hinterland until the completion of the Nanking-Shanghai Railway in 1908 and the Tientsin-Pukow line in 1912. Both Chinkiang and Nanking are on a river where it is wide and where there are no important tributaries. Water frontage is provided by only a single riverbank, and with any growth the ports would soon extend in a narrow shoestring along the stream and thus lose all the advantage of compactness. The Whangpoo is the only broad tributary entering the Yangtze between its mouth and the outlet of Poyang Lake, as far above Nanking as Nanking is above Shanghai. Both banks of the Whangpoo may be used for docks and warehouses, and the protected waters provide anchorage space for steamers, junks, and lighters. Finally, Shanghai, situated much nearer the sea than either Chinkiang or Nanking and requiring the navigation of a shorter river channel by ocean vessels, is more favorably located for entrepôt trade and for the reshipment of goods to smaller coastal ports of North and South China.

FIG. 6—On Soochow Creek and the other waterways of the Shanghai area hundreds of small boats are engaged in local transport.

IMPORTANCE OF LOCAL WATERWAYS

Waterways have acted as the feeders for Shanghai. A glance at a relief map will show that the conformation of this part of China is highly favorable to the use of waterways. Stretching to the north, west, and south is a vast alluvial plain, the largest in China, flat and

abounding in streams free from rapids. There are the Yangtze and its chief tributaries, all suitable for large vessels, and throughout the delta there are networks of smaller streams and canals, along which products are brought to Shanghai and the imports of foreign goods or the products of Shanghai factories are distributed into the interior.

FIG. 7—The floating homes of the boatmen massed at anchor in Soochow Creek. In the background is the Shanghai General Post Office.

It would be extremely difficult to compute the length of these waterways, but the total runs into several thousand miles. King estimated that in an area of some 20,000 square miles surrounding Shanghai there were 25,000 miles of canals (Fig. 12).[26] Many of the streams are tributary to Soochow Creek, the headwaters of which reach back to the city of Soochow. The Whangpoo intersects the Grand Canal at Kashing and once gave access to a considerable territory to the north and south. In recent years there has been a general neglect of the waterways. The Whangpoo is no longer navigable beyond the Chekiang boundary, and many parts of the Grand Canal are badly silted. Navigation of Soochow Creek has become difficult. Recently it was announced that Kiangsu Province and the municipal government of Greater Shanghai had reached an agreement to raise funds jointly for the dredging of the creek.

THE MINOR IMPORTANCE OF RAILROADS

Railroads have played a strikingly unimportant role in Shanghai's growth. Situated on a peninsula bounded on the north by the broad

[26] F. H. King: Farmers of Forty Centuries, Madison, Wis., 1911, pp. 100–101.

estuary of the Yangtze, on the south by Hangchow Bay, and on the east by the China Sea, the city has only a limited area accessible without the construction of large bridges. China's first railroad, nine and a half miles long, was built in 1876 from Shanghai to Woosung, situated at the point of junction of the Whangpoo with the Yangtze. Dismantled in 1877 and rebuilt in 1898, the railroad is now a part of the

FIG. 8—Junks at anchor in the Whangpoo above Shanghai

Nanking-Shanghai Railway, 204 miles long, which was completed in 1908. The second railroad serving Shanghai is the Shanghai-Hangchow-Ningpo Railway, 180 miles long, which was completed to Hangchow in 1908. In 1934 an extension of 214 miles to Yushan in Kiangsi Province was opened to service. It will be seen that the total length of railroad lines tributary to Shanghai is less than 600 miles, in contrast with 1900 miles based directly on Peiping and 1300 miles on Tientsin, and both of those centers are connected with all the railroads north of the Yangtze and in Manchuria. Until recently Shanghai had no through connection with the railroads of North China. Freight and passengers from the Tientsin-Pukow line were transferred by lighter or ferryboat across the Yangtze to Nanking. In October, 1933, a more direct connection was established when a car ferry between Pukow and Nanking was put into operation. The movement of goods to Shanghai from north of the river without the necessity of rehandling was thus made possible. The minor importance of the railroads to Shanghai is shown by the fact that the two roads tributary to the port—the Nanking-Shanghai and the Shanghai-Hangchow-Ningpo—together carried only 2,370,000 tons of freight in 1930.[27] In 1931 and 1932 their tonnage was somewhat less and averaged only 7.5 per cent of the total tonnage carried by all the railroads of China proper.[28]

The minor role of the railroads in the past would seem to have a

[27] *Statistical Monthly*, Directorate of Statistics, Directorate-General of Budget, Accounts and Statistics, National Government of China, Nanking, No. 1, October, 1931, pp. 136 and 137.

[28] *Statistics of Chinese National Railways*, year ended December 31, 1932, Nanking, p. 81.

significant bearing on the probable course of Shanghai's growth. Shanghai is a commercial center based on water transport, and it does not seem likely that rail will ever replace water as completely as the railroads have subordinated the Erie Canal and the Hudson River in serving the port of New York. The advantages of Shanghai are so distinctive, however, that railroads, as they are built in China, may

FIG. 9—The Whangpoo viewed from the mouth of Soochow Creek in the International Settlement with Pootung in the distance.

be expected to focus on the port more and more and to supplement waterways in contributing to its importance. The local difficulties of railroad construction will remain, but there will be at least extensions of the present lines. The car ferry at Nanking has connected the Nanking-Shanghai line with the railroads of North China. It is probable that a railroad will be built eventually on either the north or the south bank of the Yangtze from Nanking or Pukow to Hankow, and if that is done there will be a revival of the line already laid out from Hankow up the Yangtze to Ichang and on to Chengtu in Szechwan. It is the plan to extend the Shanghai-Hangchow line to Nanchang in Kiangsi Province and from there on to Changsha and possibly to Chungking. It is probable also that another extension will go south through Fukien Province to Kwangtung.

GEOGRAPHICAL DISADVANTAGES OF SHANGHAI

Although the geographical advantages of Shanghai have been the main factor in its development, there have been serious physical difficulties to overcome, particularly in keeping open the outlet to the sea. They are difficulties that have been present since the very beginning of Shanghai. During the Sung dynasty (960–1127 A.D.) attempts were made to clear the Woosung River (Soochow Creek) and open it out, but the flowing and ebbing tide deposited such large quantities of sand and mud that the channel was blocked almost as rapidly as it was cleared. During the Yuan dynasty (1280–1367) the

work was neglected, and influential persons hired out parts of the former river bed for use as pools and rice fields until the river was completely stopped up. Finally this abuse became so detrimental to the community that in the fourteenth century the channel was again cleared and the river made navigable. In the fifteenth, sixteenth, seventeenth, and eighteenth centuries the channel was alternately

FIG. 10—Trackers on the Grand Canal. By means of ropes attached to the tip of the mast, the junks are towed along the waterway. Note the disintegration of the old stone facings of the canal.

blocked and open according to the public interest and the ability and energy of the officials. By 1875 Soochow Creek had decreased to about its present size, and the Whangpoo had become the main stream, with a width of more than 1200 yards at Shanghai and a depth in places of six or seven fathoms. During all these centuries much of the dredging in the waters about Shanghai was undoubtedly done by farmers seeking top-dressing for their fields with bamboo pole, basket, and boats, just as they may now be seen at work in any creek or canal in the delta.

Within a very short time of the opening of Shanghai to foreign trade in 1843 ships began to experience difficulty in entering the Whangpoo because of the shallow water over the outer and inner Woosung bars. In 1863 a deputation of the leading shipping firms placed before Robert Hart, inspector general of customs, the importance of dredging the Woosung bars to permit the entrance of larger ships. Hart carried the matter to the Chinese authorities, but they refused to take any action. In fact, some of the Chinese referred to the bars as "a heaven sent barrier intended to prevent war vessels of heavy draught and iron clads from entering the harbour."[29] In 1875 Hart published a memorandum in which he said:

The trade consequent on opening the Yangtze Basin has so far been diverted into a false channel by the vested rights or money spent in Shanghai. The agency

[29] F. L. Hawks Pott: A Short History of Shanghai; Being an Account of the Growth and Development of the International Settlement, Shanghai, 1928, pp. 100–101.

is in turn counteracted by the opening of the Suez Canal, through which steamers have begun to pass, making London and Hankow their termini . . . Teas will be shipped at Hankow and Kiukiang, and Shanghai silks and Ningpo teas at Chinkiang. They will be the return cargoes of the steamers which carry what China may continue to demand from Europe. In twenty years time Chinkiang will have taken the place of Shanghai as a semi-terminus and trans-shipment port . . . Thus looked at, as it affects and is affected by natural and artificial agencies now at work at the mouth of the Yangtze, the question of the Woosung Bar is seen to mean that dredging

FIG. 11—The Pootung factory section along the Whangpoo opposite the International Settlement, Shanghai.

may possibly be nothing more than a means of making the last days of Shanghai a little more comfortable than they would otherwise be; it will not prolong or avert the commercial death of the place, but it will make a show of vitality during its declining years more possible . . . Given the natural and commercial agencies at work, it may be taken for granted that, certainly for ten, or perhaps twenty or thirty years to come, the commercial status and foreign community of Shanghai will be such as to make it worth while to prevent the river from being blocked up at any one point—for instance by the Woosung Bar. Dredging can do this and then only for a time; it cannot secure for Shanghai either a navigable channel or a continuance of commercial prosperity . . . The circumstances of Shanghai, its present position as a commercial center, the interests of the community and the revenue it yields China, are in themselves sufficient reasons why the demand for dredging ought to be assented to, but it must be borne in mind that no one can say how soon commerce may cease to ask for access to Shanghai, or natural forces acting elsewhere make dredging operations at Woosung useless.[20]

Other contemporary comments on the future of Shanghai were equally pessimistic. These prophets greatly underrated the natural advantages of Shanghai. They failed to appreciate the strength of the vested interests in the port and the possibilities of modern engineering in improving the harbor facilities. They exaggerated the advantages of the other ports, and they did not anticipate the increasing size of ocean steamers and the difficulty of navigating them any distance up the Yangtze.

THE WHANGPOO CONSERVANCY BOARD

The foreign businessmen of Shanghai continued their agitation for the clearing of the channel, and, in response, the Chinese authorities

[20] Quoted in Pott, *op. cit.*, pp. 101–102, published in full in *North-China Herald*, Shanghai, April 24, 1875, pp. 388–389.

did some dredging in the period 1889 to 1891 but with meager results. The way to the effective improvement of the harbor was not opened until the establishment of the Board of Conservancy for the Whangpoo River by the Chinese government in 1905, the government assuming sole responsibility for the work and for the expenditures connected

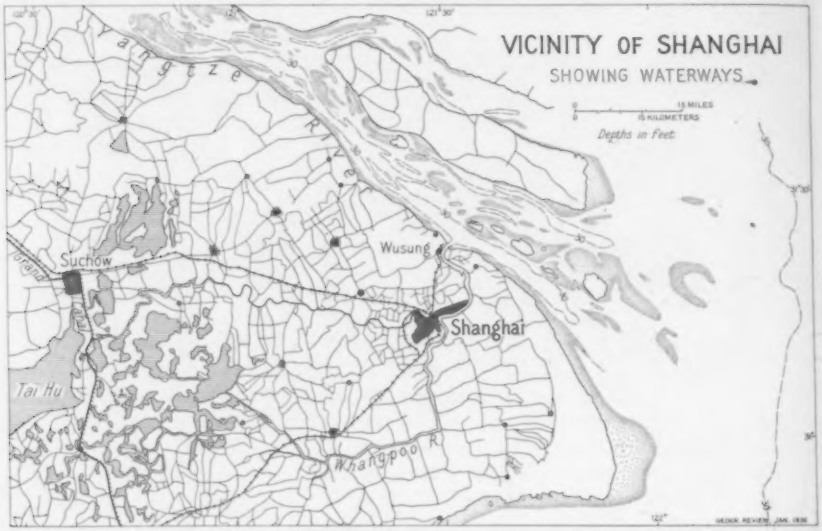

FIG. 12—Map of the vicinity of Shanghai showing waterways, towns, and larger villages. Scale: 1 : 1,700,000.

therewith. Some changes were made in 1912 in the composition of the board and in its sources of revenue, and the agency became the present Whangpoo Conservancy Board.

Since the creation of the original board in 1905 foreign engineers have been in charge of the harbor improvements. They have been greatly aided by the work of the Hydrographic Bureau of the Chinese Navy (organized 1922) in charting the Yangtze. The channel across the Outer Woosung Bar has been deepened by the construction of a training wall at the left entrance, and the Inner Bar has been eliminated by the diversion of the river from the Old Ship Channel to the more direct Junk Channel (Astraea Channel). By these measures, supplemented by dredging, a minimum navigable depth of 31 feet has been obtained through the two obstacles in place of the previous 10 or 11 feet. From Woosung to the Kiangnan Arsenal above Shanghai, a distance of about 20 miles, the Whangpoo has been canalized into a narrower and more uniform course between normal shore lines laid down in 1906 by the Conservancy Board, 1400 feet apart in the upper part and 2400 feet at the mouth. By this narrowing, the tidal currents have been aided in scouring a deeper and wider channel, and the 31-foot channel has been extended to the Shanghai water

front opposite the Settlement. As the rise of even the neap tide is 6 feet, the largest vessels of the Pacific can move about within the harbor every day of the year.[31] Formerly the large mail steamers were obliged to anchor at Woosung, the first to proceed up the river to Shanghai being the *Empress of Russia* on February 9, 1924.

Although conditions in the Whangpoo have been greatly improved, there still remains the Yangtze Bar, or Fairy Flats, a huge shoal in the south channel of the Yangtze some thirty miles southeast of Woosung. Travelers on the larger steamers are very likely to be held for several hours at the entrance to the Yangtze waiting for a high tide to float their vessel over the bar. At minimum low water there is a depth of only 18 feet over the crest of the bar. Any vessel drawing more than that may expect to be delayed several hours, and, as neap high tide rises only 6 feet, vessels drawing more than 24 feet may be delayed several days. The *Empress of Britain* with a draft of 34 feet can cross the bar on only six days of each month and only during the four hours of those days when the tides are exceptionally high.

The work of removing this final major barrier to the port of Shanghai was begun in June, 1935, when the Whangpoo Conservancy Board put a large suction dredge into operation. Some forty million tons of mud must be shifted in dredging a navigable trench across the bar 1000 feet wide and 9 feet below the crest to provide a minimum channel depth of 27 feet. The new dredge has a capacity of 5 million tons a year, and if this dredge is successful it is planned to add a second.[32]

Shanghai as an Industrial Center

At the coming of the foreigner Shanghai was an industrial town as well as a commercial center. In the account of the march of the British troops to take the city in 1842 there is a reference to buildings that they believed to be distilleries.[33] Lindsay, in his account of the visit of the *Lord Amherst* in 1832, refers to the spinning and weaving of cotton carried on by every family in the many small villages dotting the area about Shanghai.[34] Cotton seems to have been the principal crop of the farmers. An account written in 1850 says that "the husbandmen are very diligent and plant more cotton than rice."[35] It seems to be definitely established that the cotton plant was cultivated in the vicinity of Shanghai at least as early as the Yuan dynasty (1280–1367),[36] and it is probable that the cultivation dates back even

[31] Whangpoo Conservancy Board: The Port of Shanghai, *General Ser. No. 8*, 7th edit., Shanghai, 1932, pp. 112–115; *Foreign Shipping News*, U. S. Bureau of Foreign and Domestic Commerce, March 5, 1935.

[32] *North-China Herald*, 1935, February 20, p. 292; April 17, p. 106; and May 29, p. 339.

[33] H. Lang: Shanghai Considered Socially, 2nd edit., Shanghai, 1875, p. 15.

[34] Lindsay and Gutzlaff, *op. cit.*, p. 188.

[35] Medhurst, *op. cit.*, p. 46.

[36] D. B. Robertson: Cotton in China, *Journ. North-China Branch of the Royal Asiatic Soc.*, No. 3, 1859, pp. 302–308; see also Medhurst, *op. cit.*, pp. 52–55.

earlier, since the plant must have been brought to Shanghai from either South China or India during the centuries of intercourse by sea. At the time of the opening of Shanghai the output of cotton cloth was enough to supply several of the neighboring provinces,[37] and Shanghai nankeens were considered to be the best in China. It is reasonable to believe that they formed a part of the important export of cotton cloth

FIG. 13.—A bridge across the Grand Canal, high-arched to permit the passage of the tall masts of the junks.

to Europe that continued through the eighteenth century and well into the nineteenth owing to the superiority of the product of Chinese craftsmanship over the machine-made cloth of the earlier years of the Industrial Revolution. One observer stated that in Shanghai and its neighborhood two hundred thousand weavers were engaged in making plain cottons and muslins.[38] Some of the weavers were the farmers who grew the cotton, but the villagers and townspeople also manufactured cloth and yarn from raw cotton obtained in the market usually in exchange for the finished product. The principal European manufacture to enter Shanghai with the opening of the port to foreign trade was cotton cloth. In time the quality of the machine-made cloth improved, and it offered such serious competition in price to the handicraft industry that the local product gradually became of less importance. It has not disappeared, however, even with the development in Shanghai of the large modern cotton mills. Cotton is still grown around the villages and is spun and woven into a cloth that finds

[37] Medhurst, *op. cit.*, p. 65.

[38] *North-China Herald*, May 15, 1935, p. 284, reprint of an article published originally in *Penny Magazine* in 1843.

a ready sale in Shanghai chiefly to wharf workers and other laborers who prize the sturdier handmade material.

Development of Modern Manufacturing

When finally the Chinese began to accept and adopt the industrial system of the West, Shanghai was the most advantageous location for

Fig. 14—A modern factory in the Yangtzepoo section of Shanghai.

the new manufacturing industries. The Kiangnan arsenal and dockyard were established by the Chinese government in 1865. Two small silk filatures, opened in 1862 and 1866, closed within a short time, and a more permanent filature using Italian machinery and Italian experts began operations in 1880. Agitation for the construction of a modern cotton spinning and weaving mill was begun in 1881, and after some delay the mill was finally opened in 1890. Other industries followed, and in 1895 the Treaty of Shimonoseki, concluding the war between China and Japan, gave to Japan and, through the operation of the most-favored-nation clause, to all foreigners the right to establish manufacturing industries in China. Numerous factories were established by Japanese, Germans, British, and Americans, and Shanghai experienced its first industrial boom. A second boom came during and after the World War when the great demand for all kinds of manufactured goods and the difficulties of importation from Europe led to a great expansion of industrial facilities.

The present importance of Shanghai in manufacturing industries has been discussed in an earlier paragraph. The rapid development of industry is shown to some extent by the increase in the electricity

sold by the Shanghai Power Company from a total of 569,000 kilowatt-hours in 1901 to 743,510,000 kilowatt-hours in 1934.[39] This index can be taken as a fairly accurate measure of growth, since in the five years ending with 1934 the Shanghai Power Company supplied, on the aver-

TABLE I—SALES OF ELECTRICITY BY SHANGHAI POWER COMPANY TO SPECIFIC INDUSTRIES[40]

INDUSTRY	AVERAGE ANNUAL SALES 1930–1934 (*1000 kw-hr*)	PERCENTAGE OF TOTAL INDUSTRIAL SALES
Cotton mills	397,344	77.8
Flour mills	37,561	7.3
Rubber works	5,681*	1.3
Paper mills	3,887	0.76
Lumber mills	2,541	0.5
Egg-products factories	4,313	0.84
Oil mills	1,861	0.4
Ice companies	3,974	0.78
Tobacco factories	2,824	0.55
Silk mills	3,336	0.66
Miscellaneous textiles	6,542	1.28
Metalworks	2,505	0.49
Electrochemical works	4,244	0.83
Total Industrial Power	511,233	

*Four-year average, 1931–1934.

age, 83 per cent of the electricity sold by power companies in the International Settlement, the Western District, the French Concession, Chapei, Nantao, and Pootung, or practically the total area of Greater Shanghai, and in earlier years its share was even larger. Of all the electricity sold by the company in the ten-year period ending with 1934, 78 per cent was consumed for industrial purposes.

Among the modern industries that have been established in Shanghai, cotton spinning and weaving mills have taken the place of the old handicraft textile industry as the dominant manufacturing activity. Accurate evidence of the relative importance of the industries is difficult to obtain. One index is the consumption of power. It cannot be a final measure because of the varying power needs of different manufacturing processes, but it is a particularly significant index for Shanghai, since Chinese industrial statistics are so fragmentary.

The position of the cotton textile mills, consumers of 78 per cent of the power, is striking, particularly if the small consumption of

[39] Data obtained through the courtesy of W. S. Robertson, vice-president, American and Foreign Power Co., Inc., New York, parent company of the Shanghai Power Company.

[40] Personal correspondence with W. S. Robertson (see footnote 39).

power in a cotton mill relative to total output is considered. The other important industry is the milling of flour, and there are a great many factories, large and small, manufacturing rubber shoes, flashlights, paper, egg products, cigarettes, machinery, soaps and cosmetics, enamelware, toothbrushes, matches, phonographs, and a host of miscellaneous goods, mainly for consumption in the Shanghai area but in part for shipment to all parts of China where the difficulties of transportation do not make the freight charges prohibitive.

Industrial Areas of Shanghai

In the local distribution of manufacturing plants in Shanghai and its vicinity the controlling factor seems to have been transportation facilities—a river, creek, canal, or railroad. In the original areas of the International Settlement and the French Concession there are few manufacturing enterprises other than small plants supplying the consumer directly. Those parts of Shanghai were settled by the foreigners primarily for trade, and they are still the commercial and banking centers. Long before the Treaty of Shimonoseki of 1895 gave the foreigner the right to build factories in China much more extensive areas had been added to both the Settlement and the Concession. It is in those relatively less crowded areas that much of the development of manufacturing has taken place. The most important industrial area of Shanghai is the Yangtzepoo district, which lies in the International Settlement along the Whangpoo below the mouth of Soochow Creek. The first modern cotton mill of China was located there, and below the stretch of wharves near the mouth of Soochow Creek the riverbank is now lined with cotton spinning and weaving mills and some engineering and chemical works.

A second important industrial area lies along both banks of Soochow Creek, the Settlement side and the Chapei side, above the commercial area at the mouth and near the terminus of the Nanking-Shanghai Railway. The eastern part of this area is occupied by smaller establishments—silk filatures, weaving sheds, knitting mills, machine shops, and chemical works, mainly under Chinese management. Many of the factories were destroyed during the Japanese invasion of Shanghai in 1932, and the sales of industrial power by the Shanghai Power Company dropped in that year from 506 million kilowatt-hours to 452 million kilowatt-hours. Rebuilding has been rapid, and in both 1933 and 1934 there was a substantial increase in power sales over even 1931.[41]

Along the upper reaches of Soochow Creek in the Western District beyond the limits of the Settlement and even beyond the area of external roads there is another area of large factories rivaling Yang-

[41] Personal correspondence with W. S. Robertson (see footnote 39).

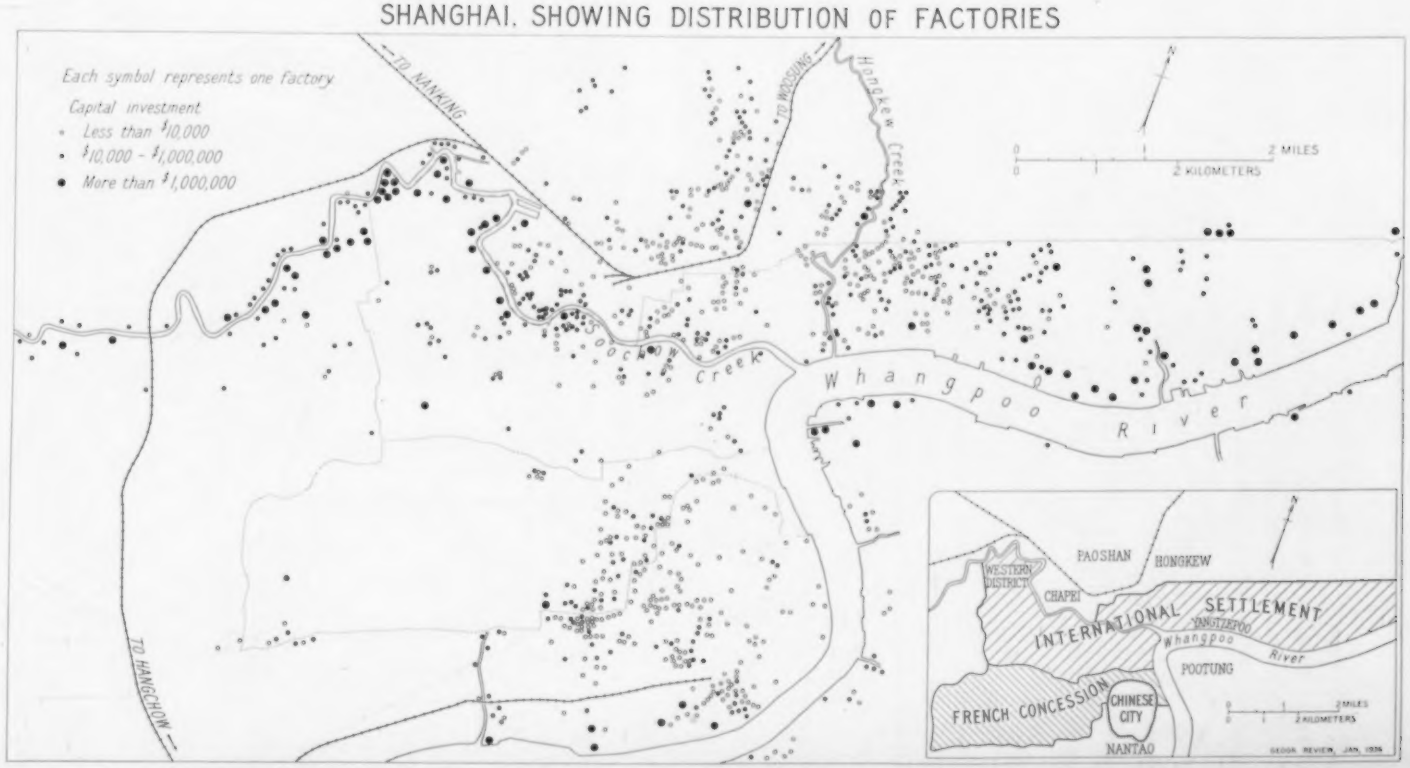

FIG. 15—Map of Shanghai showing the location of large and small factories and their concentration along the river, creeks, canals, and railways. On the inset map are shown the boundaries of the foreign settlements. (Map compiled from the map of factories of Shanghai, in Chinese, published by the Bureau of Social Affairs, Municipality of Greater Shanghai, 1928.)

tzepoo. Tributary to the spur of the Shanghai-Hangchow-Ningpo Railway linking with the Nanking-Shanghai line, it includes many cotton, flour, oil, and jute mills, chemical works, and the Kiangsu mint. Northeast of Chapei, along creeks and canals in the Hong-

TABLE II—DISTRIBUTION OF FACTORIES IN SHANGHAI[a]

	APPROXIMATE NUMBER OF FACTORIES				
	MACHINERY AND TOOLS	SPINNING AND WEAVING	FOODS	CHEMICALS	OTHERS
Western area of External Roads[b] . . .	9	23	15	7	8
Chapei, Paoshan, and Hongkew	36	91	18	55	47
International Settlement, western part[c]	7	35	17	15	33
Yangtzepoo[d]	101	43[e]	37	19	68
French Concession .	7	21	24	13	14
Chinese City and Nantao	46	44	20	57	41
Pootung	10	14	4	7	1

[a] Based on map cited in caption to Figure 15.
[b] Area west of International Settlement and of French Concession.
[c] South of Soochow Creek.
[d] Includes all of the part of the International Settlement east of Soochow Creek and north of the Whangpoo River.
[e] Includes 4 factories just outside northern limit of the Settlement.

kew district, there is an industrial area somewhat similar to Chapei, with small industries owned mainly by Chinese.

There is little manufacturing within the limits of the old walled Chinese city, southeast of the French Concession, but along the Whangpoo and around the terminal of the Shanghai-Hangchow-Ningpo Railway, both within the Concession and in Nantao, there is a concentration of small machine shops, stimulated no doubt by the large government dockyard and arsenal at Kiangnan near by. Across the river on the Pootung side, stretching downstream toward the Yangtze, are many large-scale enterprises, including cotton mills, paper factories, tobacco factories, engineering works, and the storage facilities of the foreign oil companies.

THE FUTURE OF SHANGHAI

The Chinese hold to the belief that a much greater urban concentration in the Shanghai area is inevitable and that expansion will be

of Greater Shanghai, 1928.)

down the Whangpoo toward Woosung. In 1927 the Shanghai municipality, outside the areas controlled by foreigners, was made a special district by order of the national government, with its mayor and principal officials appointed directly by Nanking. A city planning commission was created in 1929, and very shortly afterward elaborate plans were drawn up for a great, new city in the Kiangwan district, bounded by the Whangpoo on the east, the Shanghai-Woosung Railway on the west, Woosung village on the north, and the International Settlement on the south. Provisions have been made for a civic center, a system of wide avenues and roads, improved rail facilities, a new port near Woosung, and a zoning system with careful segregation of industrial, commercial, and residential areas. Work on the civic center has begun, but it will undoubtedly require many years before the new city begins to function economically to any significant extent. The established interests and the investments in the International Settlement and the French Concession are so vast that there will be no wholesale desertions of those areas. As the present port and city become too crowded, the expansion of factories and wharves and warehouses will be necessary, and it is likely that growth will be northward along both banks of the Whangpoo toward the point of its junction with the Yangtze.

Industrially, it is conceivable that Shanghai, although maintaining an absolute increase, may not be able to retain its present relative standing in China. Conditions in the past have been very favorable for the introduction of modern industries, but raw materials must be assembled from the interior of the country—raw cotton, wheat, oils, pig iron—and the finished product is returned in part to the interior. Shanghai will continue to hold its advantages for industries dependent on foreign raw materials and on foreign markets or markets in China reached by coastwise shipping, but it is likely that a number of interior industrial centers, such as Hankow, Changsha, Kaifeng, Chengchow, Tsinan, and Taiyuan, located near raw materials, will develop to supply the surrounding areas with manufactured goods, and Shanghai will suffer some relative decline in importance.

To the extent that commercial development of Shanghai depends on favorable geographical factors, there seems to be no reason to expect anything but continued growth. The Yangtze River will continue to be the principal artery of central China, and its trade should grow with the economic expansion that will follow political stabilization. There must be a great port near its mouth, and no other site is so well located, especially in view of the improvement to the approaches to Shanghai accomplished by the Whangpoo Conservancy Board. There are no indications that any other port of China, north or south, is likely to challenge seriously Shanghai's position as the country's leading commercial center.

In the future of Shanghai there are two questions, both political. One is the fate of the capitulations forced from China by foreign powers; the other is the extent of Japanese ambitions. If China is able to attain any substantial degree of political unity, it is possible that the powers will be forced to surrender both their right of extraterritoriality and their privileged position in Shanghai and in other parts of China, just as the British have already surrendered their concessions in Hankow and Kiukiang. Under complete Chinese sovereignty will Shanghai be able to hold and expand the economic leadership reached during the last century?

Japanese ambition suggests the possibility of a very different development. Will Japan be content with the gains in Manchuria and North China? Will the attempt be made to extend Japanese hegemony to the valley of the Yangtze, and if that attempt is made can it succeed unless the control of Shanghai passes into the hands of Japan?

CHINA AND THE FLOW OF SILVER

Frank Whitson Fetter

WITH MAPS AND A NOTE

Herbert M. Bratter

FIG. 1—A Shanghai sycee (silver shoe).

China is a conservative land with deep-seated monetary customs and prejudices, many of them differing markedly from province to province. These variations in monetary practices are in many cases associated with trade routes and regional differences in economic and political conditions. China, moreover, is a country where silver has long been the principal medium of exchange, a fact that has created some peculiar financial and commercial relationships between that country and the rest of the world. The Chinese monetary situation is closely related to conditions in the world silver market and to economic and political policies in other countries and hence is an important element in the present international economic situation.

For decades India was the center of interest in any discussion of silver. Until her mints were closed to free coinage in 1893 she was economically the most important country on the silver standard; and until the middle of the 1920's she remained the world's greatest purchaser of silver, both for coinage and for hoarding. But China has become a factor of increasing significance in the world's silver market. She was for many years the only large country on the silver standard;[1] after 1927 she replaced India as the greatest purchaser of silver; and recently the stocks of silver in Shanghai have come to assume much importance in the silver market.[2]

China, despite the great use that she makes of silver, has few silver mines, and in recent decades her production has been but a fraction of one per cent of the world's total. Almost all of her hoards of silver have come in the last three centuries from the mines of the

[1] China has not been on a full silver standard since October, 1934. Under a silver standard a country's monetary unit is equal in value to a fixed amount of silver in a free market. In October, 1934, China placed obstructions on the export of silver that lowered the value of the Chinese dollar considerably below its bullion parity.

On November 3, 1935, China definitely abandoned silver for external payments when the Finance Minister "declared that banknotes issued by the government-owned Central Bank of China, Bank of Communications and Bank of China become legal tender . . . Debts specifically payable in silver dollars may be settled in the new legal tender and all holders of silver must surrender it to the Central Bank and accept notes in exchange at face value" (*New York Times*, Nov. 4, 1935).

[2] See Professor J. E. Orchard's paper on Shanghai in the present number of the *Geographical Review*.

New World through trade with Europe and America. China has, since her first contact with the West, been a net importer of silver.[3]

The Silver Currency of China

Very little silver was in use as money in China until after the Portuguese and English established trading relations. In the journal of Marco Polo and the accounts of other Europeans who made overland journeys to China in the Middle Ages there is almost no mention of silver in monetary use. Before trade with Europe began, the money of China consisted largely of copper "cash," the traditional Chinese coins with the square holes.

The opening of maritime trade with Europeans brought in large quantities of foreign silver, mostly Spanish pieces of eight, generally spoken of as "pesos" or "Carolus dollars" (Fig. 2). This Spanish coin, made from silver taken from the mines of Mexico and Peru and generally minted at Mexico City or Potosí, was the coin that the Yankee sailing ships carried to the Far East in the trade that laid the basis of many a New England fortune. It and its successor, the Mexican dollar, were for nearly three centuries the principal silver coins not in China only but in most of the Orient. Although no longer current in the port cities of China, as late as 1930 it still circulated in some places in the interior.

After the Spanish possessions in the New World won their independence, the Carolus dollar was no longer coined; but it remained the only coin widely used in wholesale business in China until the 1850's, when it was replaced by the new dollar of the Republic of Mexico, popularly known as the "eagle dollar" from the figure of an eagle holding a snake in its mouth. Many other foreign dollars have circulated in China, but none since the passing of the Carolus dollar have ever enjoyed the prestige or the popularity of the Mexican dollar. Several countries have minted coins intended especially for the China trade: the United States in 1873 authorized a "trade dollar" for use in China, and similar action was taken by the French, British, and Japanese. Coinage of the American trade dollars was stopped in a few years, but the small number that went to China enjoyed a good reputation. As late as the time of the World War American trade dollars were current in remote places in the interior. Next to the Mexican dollar, the most widely used foreign coin has been the British or Hong Kong dollar, commonly known among the Chinese as the "standing man" dollar.

[3] Complete statistics on the silver exports and imports of China before 1888 are not obtainable, but all the available evidence indicates that before that year the country was a large net importer. Between 1888 and 1932 China's net silver imports were in excess of a billion ounces.

All statistics on silver imports and exports from 1888 to 1931 used in this article are taken from figures published in H. M. Bratter: The Silver Market, *U. S. Bur. of Foreign and Domestic Commerce Trade Promotion Ser. No. 130*, Washington, 1932, pp. 85–86. Figures from 1932 to 1935 are taken from the *Monthly Returns of the Foreign Trade of China* of the Chinese Maritime Customs.

Around the circulation of these various foreign dollars (see Fig. 4, c, p. 46) might be written much of the history both of trade routes in China and of spheres of foreign political influence: for instance, in the province of Yunnan,[4] adjoining French Indochina, the French trade dollar, commonly called the Saïgon dollar, has had its greatest circulation; in the province of Fukien, where Japanese influence is strong, the Japanese silver yen has been much used. The Hong Kong dollar has been very popular in North China, where for a time it was at a slight premium over other dollars. It was also used extensively in trade with Mongolia and through this trade has been carried to many remote places in western China. The American trade dollar seems to have been rapidly drawn into the interior through the Yangtze River trade, and long after it had passed out of circulation in the seaports it was found in the country in the upper Yangtze basin.

In 1905 Mexico went on the gold standard, and its historic silver-standard dollar was no longer minted. But the downfall of the Mexican dollar's supremacy in China really dates from 1898, when the design was changed. Although no change was made in the weight and fineness of the new coin, it was different from the old. That for the average Chinese was reason enough to distrust it, and very few Mexican dollars minted after 1897 ever circulated in China. With no new supplies of Mexican dollars forthcoming, great numbers of Hong Kong dollars came into circulation.

It was not until several years after the overthrow of the Manchu dynasty in 1911 and the establishment of the republic that really effective steps were taken to replace the foreign dollars and to introduce a Chinese currency (Fig. 2). In 1914 silver dollars—or yuan, as they were officially called—bearing the figure of Yuan Shih-kai, then president of China, were minted. These dollars became very popular after a few years and circulated in almost every part of the country. But here again the attitude of the Chinese illustrates the resistance to change in the Middle Kingdom. The first of the Yuan Shih-kai dollars carried the inscription "Third Year of the Chinese Republic" (1914), and in some of the outlying provinces any deviation from this design discredited the coins, even though of proper weight and fineness.[5] Yuan Shih-kai dollars are no longer minted.

A number of other dollars of weight and fineness about equal to those of the Yuan Shih-kai dollar, but with different designs, have

[4] For a map showing provinces and places mentioned in the text of this paper see Figure 2 on page 10 of the present number of the *Geographical Review*.

[5] After 1914 some of the Chinese mints, because of this prejudice, turned out Yuan Shih-kai dollars bearing the inscription "Third Year of the Chinese Republic" (Eduard Kann: The Currencies of China, 2nd edit., Shanghai, 1927, pp. 161–162).

A similar situation is found in the case of the Austrian Maria Theresa dollars. Coins bearing the date 1780 were very popular in Ethiopia, and this dollar became the principal medium of exchange. Since 1780 many mintings of this coin, still bearing the date 1780, have been made at the Austrian mint for use in Ethiopia.

FIG. 2—Some silver dollars current today or formerly in China. *Foreign dollars*: Carolus, 1802; Mexican, 1854; Japanese trade; American trade, 1876; Hong Kong, 1912. *Chinese dollars*: Yuan Shih Kai; Sun Yat Sen, obverse (lower left); Sun Yat Sen, reverse (showing junk). Photographs approximately size of originals of coins in the collection of the American Numismatic Society, New York.

The cuts on the Carolus, Mexican, and American trade dollars were commonly known as "chops" and were made by stamping with metal dies. The chop was similar to the endorsement on a check and was a guarantee by the person putting his chop on the coin that it was genuine. The practice of chopping, formerly common, especially in South China, has been passing out in recent years, and in many places in China dollars disfigured by chops are no longer accepted.

The Sun Yat Sen dollar here shown is one that was first minted by the new National Mint in Shanghai in 1933. Before that time many dollars, bearing the figure of Sun Yat Sen but made from different dies, were coined at the provincial mints.

been issued under the republic. The only ones to be issued in large quantities and to have a wide circulation are those bearing the figure of Sun Yat-sen. With no further supplies of other Chinese dollars forthcoming and with most of the foreign coins that have been current in China no longer minted, it seems only a question of a few years until the Sun Yat-sen dollars will be dominant.

Monetary Standards in China

Although China, before the restrictions placed on the export of silver in October, 1934, was generally spoken of as a silver-standard country, this statement suggests a false picture to a person who thinks in terms of the monetary systems of Western nations. Silver, it is true, is the metal in which customs import duties were assessed until 1930, in which most other taxes are still assessed, in which the larger part of the foreign trade and the wholesale business of the country has been carried on, and in which most domestic loans have been made. But monetary standards other than silver have been so important in China and there has been such diversity of practice in the use of silver that one may not properly speak of the country as being on a single monetary standard. In one city Chinese dollars would be at a premium in terms of Mexican dollars, in another city at a discount. Much of the retail business in the interior and even in some of the larger cities is carried on in an independent copper currency (Fig. 4, Map e), whose value in silver fluctuates daily. In several provinces, notably Hupeh, Shantung, Honan, and Kiangsi, a large part of the sales and purchases by Chinese farmers is in terms of copper, and in some places even taxes are paid and loans contracted in terms of copper. In the southern provinces of Kwangsi and Kwangtung very few silver dollars have been used in the last fifteen years. The principal medium of exchange and standard of value has been silver in denominations of 10 and 20 cents, commonly called "small money" to distinguish it from the silver dollars, or "big money." These fractional coins were originally minted as fiduciary coins as part of the "big money" system, but owing to overissues they depreciated below parity with the standard full-weight coins. They have generally had a slight premium over their bullion value, and as their value in "big money" fluctuated daily according to factors of supply and demand, they really constituted a separate monetary standard divorced from silver. Since 1930 customs import duties have been collected on a gold basis, though payment is generally made in silver or other local currency, at the rate of exchange of the day. Inconvertible paper money has been extensively issued by war lords of the various provinces, especially in the past decade, but these issues generally have only a local circulation.

In the three Manchurian provinces, which now form Japan's dependency of Manchukuo, silver dollars were very rare for many years before the provinces were separated from China, and the currency consisted principally of inconvertible paper money issued by provincial authorities, Japanese yen in the Japanese spheres of influence, and a few silver-standard bank notes generally redeemable not in silver itself but in drafts on Shanghai. Although almost no silver circulated, there was a considerable demand for silver dollars, particularly the "standing man" dollars, from merchants trading with Mongolia. To complicate the situation still more, "small money" from South China was the standard in some transactions in southern Manchuria. A few years ago a company operating several mines there paid its Chinese employees on three different bases: at one mine in "small money" fractional silver, at a second in provincial paper money, and at a third on the basis of "big money" silver dollars, though actual payment was made in paper money at the prevailing exchange rates. The money-changer does a flourishing business, and in 1930 the writer observed ten exchange shops within three blocks in Harbin—not an unusual occurrence in many parts of China.

A most interesting feature of the silver situation in China has been the tael money of account, which a few decades ago was widely used in the principal cities and was finally superseded by the silver dollar in Shanghai, its last stronghold, in April, 1933. The tael, a Chinese unit of weight corresponding roughly to our ounce, varies greatly from city to city, just as in early England an ounce varied in weight throughout the country. The Shanghai tael money of account was established by the merchants of that city in 1857, when a serious situation was created by the scarcity of Carolus dollars, and for more than 75 years the Shanghai tael remained supreme as the money of account in wholesale transactions in Shanghai. The silver basis of this monetary system was in the form of ingots or shoes (Fig. 1). The silver in these shoes was generally spoken of as "sycee." The shoes, ordinarily containing about 50 ounces of silver, did not pass in hand-to-hand circulation but were used in the settlement of balances between Shanghai banks. Anyone carrying on extensive business operations in Shanghai had to keep both a tael and a dollar account. Whether a particular transaction was carried on in taels or in dollars was not a matter of law or of any apparent logic. House rent and gas and electric bills were ordinarily payable in taels, as were doctors' and dentists' bills and the salaries of municipal employees; wholesale transactions in some products were in taels, in other products in dollars. For his purchase of gasoline the auto owner paid in dollars, but for tires and extra parts he often paid in taels. The history of the Shanghai tael brings out clearly several of the outstanding characteristics of Chinese life: the dominance of custom, the distrust of government,

and the importance of guilds in regulating the economic life of the country. The making of the sycee was controlled entirely by the silversmiths' guild, and it was inspected and its weight and fineness were certified by the Kung-ku-chu, or public assayers' guild.

Effect on China of Changes in the Price of Silver, 1874–1914

As long as the price of silver in terms of gold—or, as the Chinese look at it, the price of gold in terms of silver—was stable, the fact that China was on the silver standard in her foreign trade and wholesale business did not make the situation materially different from that which would have existed with a gold standard. For more than two centuries before 1873 the ratio of gold to silver had always been between 14½ : 1 and 16 : 1, which represents a maximum fluctuation of about 10 per cent in the gold price of silver. But beginning in 1874 there was a gradual decline, which lasted for almost thirty years, in the gold price of silver. From 16 : 1 in 1873 the ratio rose to more than 40 : 1 in 1902.[6] This meant that the Chinese dollar—or tael—was worth less than half as much in American dollars or English pounds as in 1873. Complications were thus created in China's foreign trade, and difficulties arose for those who received silver in payment and had obligations in gold.

However, the difficulties arising in China from this decline in the gold price of silver have frequently been exaggerated. Until the 1890's the decline was due to the rise in the value of gold rather than to a fall in the value of silver. From 1873 to 1890 prices were more stable in China than in gold-standard countries, and they rose in the 1890's, so that China escaped the falling prices that caused distress in the United States and Europe in the closing decades of the century.[7] In the period from 1896 to 1914 the gold price of silver was much more stable than it had been from 1873 to 1896.

The difficulty that this fall of silver created for Chinese debtors with gold obligations has also been misunderstood. In so far as the decline in the price of silver was due to an appreciation in the purchasing power of gold, there was clearly an increased burden, as compared with earlier times, on Chinese who had to pay debts in gold. But the basis of this increased burden was not the existence of the silver standard but the appreciation in the purchasing power of gold. In gold-standard United States, farmers who had to sell two bushels of wheat to obtain as many dollars as they had previously obtained with one bushel and businessmen who found that the profits of a year's operations were much less in terms of dollars than before were

[6] All statistics on the price of silver (except daily quotations) used in this article are taken from H. M. Bratter: Silver Market Dictionary, New York, 1933, pp. 113, 114, and 118.

[7] For a discussion of changes in the gold price of silver in relation to changes in general commodity prices see Bratter, The Silver Market, pp. 25–30 and 79–80.

in a situation similar to that of the Chinese. The Chinese, as long as their debts were payable in gold, would not have escaped the increased burden by shifting to the gold standard; they would merely have felt the burden in a different way. After 1896, when the purchasing power of gold was falling, the situation was somewhat different, though the principles involved were the same. It is true that complications were introduced by the depreciating exchange and that many people suffered, as is always the case when economic relationships are changing; but it is a mistaken idea that China as a nation suffered seriously from the decline in the gold price of silver between 1870 and about 1902 and the continued low price until the outbreak of the World War.

Effect on China of Changes in the Price of Silver, 1914–1934

During the latter years of the World War and in 1919 and the early part of 1920 the gold price of silver rose rapidly, reaching a figure that had not been touched since 1873. The silver dollar, worth only 37 cents in 1902 and only 42 cents at the outbreak of the war in 1914, was worth more than a gold dollar late in 1919 and early in 1920. It was not a rise in the purchasing power of silver that increased the price of silver but a decline in the purchasing power of gold, as manifested in the high commodity prices of 1917 to 1920 in the United States. In China prices in terms of silver were relatively stable during the war and early postwar years, and China escaped the rigors of wartime inflation and postwar deflation experienced by countries on the gold standard (Fig. 3). Although the Chinese received far fewer silver dollars for an American dollar than they had in 1914, the products they bought and the products they sold abroad brought so much more in terms of gold that the prices in terms of silver were about the same in 1920 as in 1914.

After a sharp fall in 1920 the gold price of silver was relatively stable from 1921 to 1925, fluctuating between 63 cents and 74 cents an ounce. The most important developments in the Chinese silver situation after 1921 were the continuation of large annual imports of silver and the slow but steady increase in the stock of silver held by the Shanghai banks. In every year from 1918 through 1932 China had a net excess of silver imports. The silver stocks in Shanghai, which as late as December, 1923, were as low as 44,850,000 ounces, rose to 134,270,000 ounces in October, 1926[8]—a foreboding of the still greater increase that took place between 1928 and 1934. In much the same way that American banks keep funds in New York, banks in the interior of China keep large balances in Shanghai and thus concentrate the Chinese monetary reserves in that city. Until 1925

[8] All figures on Shanghai silver stocks are from Handy and Harman's *Review of the Silver Market*, published annually in New York.

the increase in Shanghai monetary stocks was moderate. It represented but a small portion of silver imports, the remainder going to other ports and to the interior. But from 1925 until 1934 there was an abnormal increase in the Shanghai stocks as a result of both domestic and international conditions. Political disorder in the

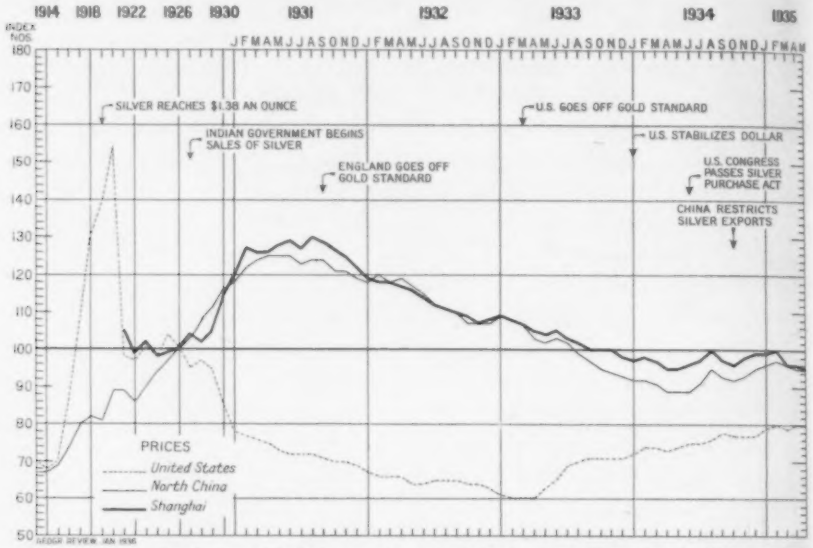

FIG. 3—Graph showing trend in index numbers of wholesale commodity prices in China and the United States 1914–1935. 1926 = 100. Index numbers for the United States prepared by the U. S. Bureau of Labor Statistics (*Federal Reserve Bull.*, Vol. 20, 1934, p. 527; Vol. 21, 1935, p. 521; *Ann. Rept. of Federal Reserve Board* for 1933, p. 250) for North China by Nankai Institute of Economics, Nankai University, Tientsin; for Shanghai by the National Tariff Commission, Shanghai (*Shanghai Market Prices Rept.*, Oct.-Dec., 1932, pp. 27 and 31; Oct.-Dec., 1933, pp. 10 and 12; Prices and Price Indexes in Shanghai, May, 1935, pp. 2 and 6).

interior of the country and the growth of brigandage not only reduced business activity and the demand for loans but also led to the looting of interior banks by bandits and military chieftains. Both considerations of banking policy and precautions against looting fostered a movement of silver from the interior to Shanghai. With the world depression, the reduced market abroad for Chinese goods contributed to this movement of silver, since it was shipped from the interior to make payments that had previously been made by the shipment of goods. The result of these conditions was an increase in Shanghai stocks from 102,680,000 ounces in June, 1928, to 322,590,000 ounces in December, 1932, and to an all-time high of 449,840,000 ounces in June, 1934—an increase in six years of nearly 350,000,000 ounces, an amount about equal to the net silver imports of all China in the same period. These large Shanghai stocks came to exercise a depressing effect on the world silver market.

For several years before April, 1933, silver had flowed into Shanghai both from the interior and from abroad with only minor interruptions

(Fig. 4, Maps a and b). In 1933 and early in 1934 the flow of silver from the interior continued, but beginning in April, 1933, there was an export of silver, principally from Shanghai, to foreign countries. After the American Silver Purchase Act, calling for the purchase of large quantities of silver by the American government, was passed in June, 1934, these silver exports continued on a much larger scale.

Before considering the sensational developments that have taken place in the Chinese silver situation since the passage of this act, it is necessary to review briefly the course of silver prices after 1929. Silver, which had declined from an average of 69 cents an ounce in 1925 to an average of 53 cents an ounce in 1929, fell sharply in 1930 and 1931 and reached a low point of 24½ cents an ounce in December, 1932. This gave the Chinese silver dollar a gold value of less than 19 cents. An important factor in this decline in the gold price of silver was the decision of the Indian government in 1926 to increase its gold reserves and to dispose of some of its silver reserves. The result was that the Indian government, which for years had been a buyer of silver, became a seller in 1927 and for the next five years sold about twenty million ounces annually—an amount equal to about 10 per cent of the world's production. Large amounts of demonetized silver were also sold by French Indochina, Siam, and several European countries. There was also some decline, after 1926, of private imports of silver by India.

This drop in the price of silver, coinciding as it did with world depression, led to a great agitation, particularly in the western part of the United States, that "something be done for silver." It was even argued that the decline, by destroying the purchasing power of the Orient, had been a primary cause of the depression. An increase in the price of silver was pictured as the means of restoring the buying power of India and China and bringing the world out of the depression. This argument received much support in high circles both in this country and in England, despite the fact that it flew in the face of all statistical evidence and was fallacious in several ways. As applied to India, it assumed that India, because a large part of the money of the country consisted of silver rupees, was on the silver standard and that the value of the rupee fluctuated with the price of silver. In fact, the silver rupee is a fiduciary coin, whose value is tied to the British currency, and it no more fluctuates with changes in the price of silver than the American dollar bill fluctuates with changes in the price of paper, the American dime with changes in the price of silver, or the American cent with changes in the price of copper. As regards China, it was of course true that the silver dollar and the tael fluctuated in gold value with fluctuations in the price of silver. But the assumption that the purchasing power of China would be increased by a rise in the gold value of silver ignored the facts

that China was ordinarily an importer of silver, that she paid for foreign goods, not with silver, but with Chinese goods, and that American exports to China had held up better than elsewhere.[9]

Although the fall in the general price level in gold-standard countries after 1926 made the decline in the purchasing power of silver much less than might appear at first glance, there was, nevertheless, some decline.[10] As a result, China, particularly the port cities, went through an inflation from 1926 to 1931 (Fig. 3). Far from being prostrate from any "decreased purchasing power" as a result of the silver situation, the ports of China, at a time when Western countries were in the grip of depression, were experiencing the Oriental counterpart of America's stock-market boom. This was especially true in Shanghai, where there was extensive speculation in real estate.

Effect of the Silver Policy of the United States

Although the Chinese government had signed the American-sponsored agreement intended to stabilize the price of silver, which had been drawn up at the London Economic Conference of 1933, it was extremely apathetic toward proposals to "do something for silver." Both Chinese and foreigners prominent in the commercial life of China expressed their opposition to any abrupt increase in the price of silver by governmental action. Nevertheless, the American Congress passed in June, 1934, a silver-purchase act, calling for large additions of silver to the monetary reserves of the country. Although the principal reasons for this action seem to have been to benefit American silver-mine owners and increase commodity prices in the United States, the assertion was also made that it would raise the purchasing power of China, thus benefiting the Chinese and increasing American exports.

After the suspension of the gold standard by the United States in the spring of 1933 the price of silver rose rapidly in terms of dollars, though actually the price in terms of gold changed little between April, when the dollar fell below its gold parity, and January, 1934, when it was stabilized at 59.06 per cent of the old parity.[11] But the aggres-

[9] Competent technical discussions of this problem are found in F. D. Graham: The Fall in the Value of Silver and Its Consequences, *Journ. of Polit. Econ.*, Vol. 39, 1931, pp. 425–470, and T. J. Kreps: The Price of Silver and Chinese Purchasing Power, *Quart. Journ. of Economics*, Vol. 48, 1933–1934, pp. 245–287.

[10] In New York silver fell from an average of 62.1 cents in 1926 to its lowest annual average of 28.7 cents in 1931, or 46 per cent of the 1926 price. The Bureau of Labor Statistics' index number of wholesale commodity prices in the United States fell from 100 to 71 in the same period, an indication of a decline in the purchasing power of silver over other commodities of about 35 per cent.

[11] On April 17, 1933, two days before the embargo on gold exports caused the dollar to fall below par, the price of silver in New York was 28⅝ cents an ounce; on January 31, 1934, when the dollar was stabilized at 59.06 per cent of its old parity, it was 44 cents, or 26 cents in terms of the old dollar. As late as June 19, 1934, the day the Silver Purchase Act was signed, silver was quoted at 45⅝ cents an ounce, or only 27 cents in terms of the old dollar.

All daily quotations for silver and for Chinese exchange given in this article are from the *New York Times* of the following day

sive policy of silver purchase followed by the United States Treasury after June, 1934, caused the gold price of silver to rise from 41¾ cents on May 1, 1934, to a high of 81 cents on April 26, 1935. This sensational rise was accompanied by an unprecedented export of silver from China: more than 170,000,000 ounces in the last six months of 1934, according to customs records, in addition to an unrecorded amount that was smuggled out. From 449,840,000 ounces on June 30, 1934, Shanghai stocks fell to 261,548,000 ounces on December 29 of that year. After this rise in the price of silver the market reacted sharply, and at the present time (October 18, 1935) silver is quoted at 65⅜ cents.

As long as there was free export of silver the gold value of the Chinese dollar was tied to the gold price of silver. In October, 1934, in an effort to stop further appreciation in the silver dollar and to protect the reserves of banks, the Chinese government placed an export tax of 10 per cent on silver, plus a special equalization charge that varied with the price of silver. In addition, arrangements were later made with the banks that practically stopped the export of silver, even though payment of the export duty and equalization charge would still have given a profit to the exporter. The result was that the Chinese exchange rate was divorced from the gold price of silver and the Chinese dollar ceased to be a silver-standard currency. On December 1, 1934, when the bullion parity of the Chinese dollar, based on the price of silver in New York, was 42 cents, the Shanghai dollar was quoted on the exchange at only 34 cents; by April 26, 1935, this difference had risen to 20 cents, the bullion parity being 62 cents and the actual exchange rate 42 cents. This situation may be brought out more clearly by comparing the foreign-exchange quotations of the silver dollar at Shanghai and at Hong Kong, where the export of silver is permitted. The Hong Kong dollar and the other silver dollars current in the colony have the same silver content as the dollars current in Shanghai, yet on April 26 the Hong Kong dollar was quoted at 62 cents, almost exactly bullion parity. On October 18, 1935, when the bullion parity was about 50 cents, the Hong Kong dollar was quoted at 49 cents and the Shanghai dollar at 36 cents.

Such a situation offers an alluring profit to smugglers. Reports from China indicate that extensive smuggling has already taken place, and the large movement of silver from Shanghai to other ports of China in recent months is generally interpreted as connected with smuggling operations. The experience of many other countries has shown that such an embargo on the export of a precious metal cannot long be effective. The Chinese exchange rate is almost certain to come in line with world silver prices, as a result either of the smuggling operations, which will raise the exchange value of the Chinese dollar

and thus accentuate the deflation in China, or of a decline in silver prices to nearer the level of June, 1934.[12]

As was pointed out earlier, the silver situation not only enabled China to avoid in 1930 and 1931 the deflation that had hit the Western world but also gave to Shanghai and other cities a boom during the early years of the world depression. In the latter part of 1931 commodity prices started downward, and in the following year and a half China suffered the pains of deflation. The index of wholesale prices in Shanghai fell from a high of 130 in August, 1931, to 98 in December, 1933; in North China the index fell from a high of 125 in June, 1931, to 95 in December, 1933. Although the downward trend of commodity prices had almost ceased by the beginning of 1934,[13] the years 1934 and 1935 brought a critical financial aftermath. The situation has been particularly acute in Shanghai, where the speculative boom of the latter twenties and early thirties created an unstable financial structure. Several Chinese banks have failed, and in May, 1935, the American-owned American Oriental Bank, which had been closely associated with the Shanghai real-estate boom, closed its doors, as did a number of other concerns closely affiliated with this bank. Not only was the failure a great shock to business confidence in Shanghai, but it has caused severe loss to the American community, particularly to missionaries and missionary organizations, which had large deposits in the bank.

Many who have suffered from this and other failures have put the blame for the development on the American silver policy. A couple of years ago the silver interests shed tears over the poor Chinese whose "purchasing power had been destroyed," and now the fate of the Chinese has become the special concern of critics of our silver policy. Yet it is easy to exaggerate the deflationary effects on China of the American silver-purchase policy. The drop in Chinese commodity prices that took place before 1934—a large part of it before the United States went off the gold standard in the spring of 1933—cannot be charged to the Silver Purchase Act of 1934. On the other hand, the heavy exports of silver in 1934 clearly put pressure on the banks, particularly in Shanghai. Under any conditions, there would have been a reaction from the speculative excesses of the years before 1932. All that can be said with assurance is that the American silver policy brought the collapse more quickly and made it severer than it would otherwise have been. But whatever the American silver program may have done to Chinese economic life, it has effectively laid the

[12] The recent action of the Chinese government, taken while this article was in press, suspending the redemption of bank notes in silver and making this inconvertible paper money legal tender, of course makes it possible for the Chinese Exchange to remain permanently out of line with world silver prices.

[13] The index of wholesale prices in Shanghai was 97 in January, 1934, and 95 in May, 1935; in North China the indexes were 96 and 95 respectively.

ghost of the decline in the price of silver as destroying the purchasing power of the Orient and bringing on depression; it has demolished the idea that artificially raising the price of silver would help China or cure the world depression.

The Future of Silver in China

What the future of silver in China will be, no one can say. Forty years ago a number of countries, including Japan and Mexico, were still on the silver standard; today China, although temporarily departing from a genuine silver standard, remains the only important adherent to silver as the basis of a monetary system. Some years ago it seemed likely that China would abandon silver and adopt the gold standard. The programs for putting China on the gold standard that have been worked out by various individuals and monetary commissions, both foreign and Chinese, and the criticisms and comments evoked by these plans would fill a good-sized library. But the probability of China's adopting the gold standard in the near future seems less now than it did before 1929. The suspension of the gold standard by so many countries during the depression and the attitude of skepticism toward the gold standard held in many influential circles today have undoubtedly contributed to that situation.

If and when China moves toward the gold standard, she will not make the transition in one step, as Germany did in 1873, Japan in 1897, and Mexico in 1905. Things do not happen that way in China. Even if business in the ports is shifted to a gold basis, it is not likely that in the interior the copper and silver coins now circulating could be stabilized in terms of gold or the inconvertible paper issues of the local war lords suppressed for some years to come. Custom and tradition are too strong, the country is too vast, and public distrust of government is too great to permit an overnight change to a new monetary system.

APPENDIX—CHINA AND WORLD SILVER MOVEMENTS

A NOTE ON THE ACCOMPANYING MAPS

Herbert M. Bratter

THE altered position of China in the world silver market during the last few years is strikingly revealed by the accompanying maps of the world flow of silver (Fig. 4, Maps a and b), which show the principal international movements of silver in 1930 and 1934. In 1930, when the world depression had only begun and while China was still obtaining some shelter from it owing to the contemporary decline in silver and export commodity prices, the chief movements of silver found their destination in the Middle Kingdom and British India. The trend in predepression times is indicated by the arrows on the upper map. The black squares representing new production of silver are counterbalanced by the shaded squares

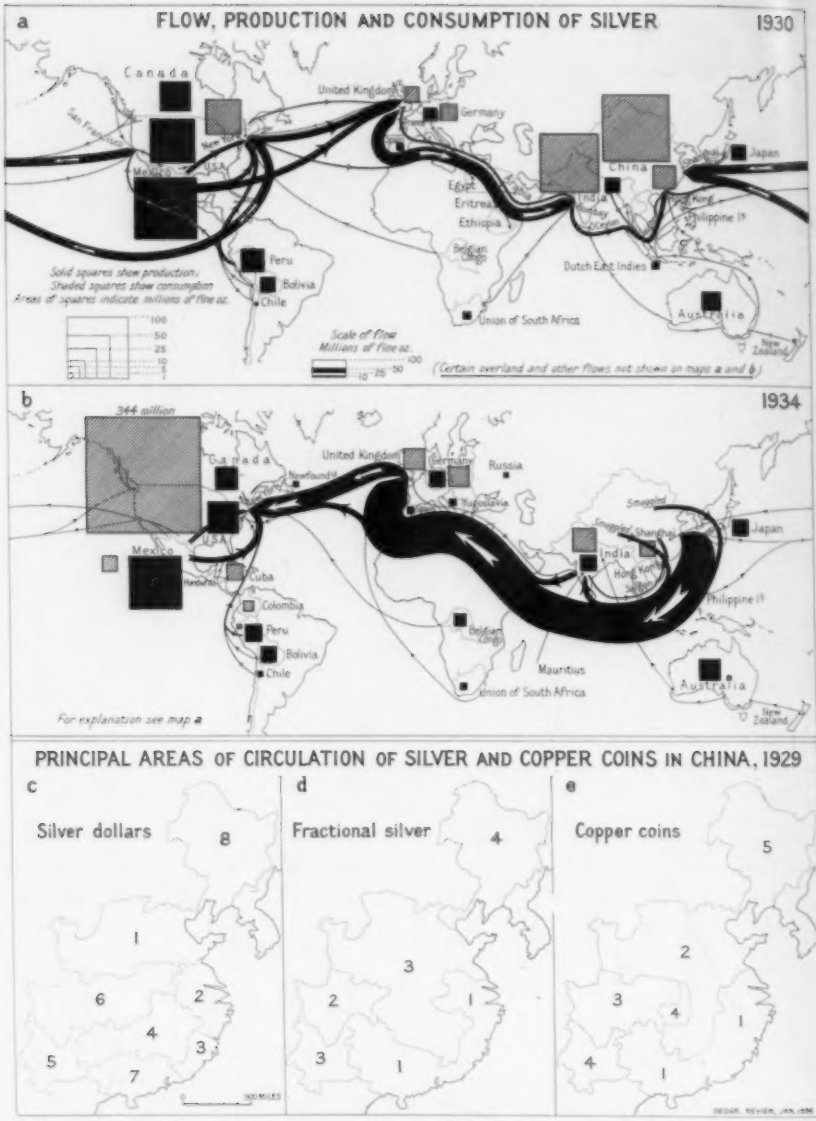

FIG. 4—For further explanation of these maps and references to the sources on which they are based see Dr. H. M. Bratter's note on page 47. Key to reference numbers on maps of China:

Map c: 1, British dollars; 2, Mexican dollars; 3, British dollars and Japanese yen; 4, Chinese dollars, very few foreign dollars, mostly at a discount; 5, limited circulation of Chinese dollars and Saigon dollars; 6, only Chinese dollars; 7, few dollars in circulation; subsidiary coins are standard money; 8, practically no dollars in circulation.

Map d: 1, 20-cent coins, a few 10-cent coins in some places; 2, 50-cent coins; 3, very limited circulation of fractional silver; 4, practically no fractional silver in circulation.

Map e: 1, 10-cash coins; 2, 20-cash coins; 3, 100 and 200-cash coins; 4, 20, 50, 100, and 200-cash coins (border region); 5, very few or practically no cash coins in circulation.

representing the absorption of the metal by China, British India, and, to a minor extent, by the arts and industries in Occidental countries.

In contrast is the situation today, as revealed by the map for 1934. The mine production of the New World flows no longer to Europe and the East but to the American market. Our large Treasury purchases in London, moreover, have been drawing on China to an extent that dwarfs not only the current mine production but the 1930 eastward flow of silver. India's huge silver stocks were still detained there in 1934 owing in part to the barrier of an import duty, which made silver more valuable within India than without. If the price of silver should rise materially, however, the Indian stocks would begin to move. (Stocks of silver are not shown on the maps.) The Chinese outflow in 1934 was partly smuggled, but mostly legitimate; in 1935 legitimate exports of silver from China were negligible, but the gross outflow was considerable.

Not only the thickness and direction of the flow lines but also the shaded "consumption" squares reveal the change since 1930. Today silver is being both produced and consumed preponderantly in the New World, thanks to the American Silver Purchase Act of 1934. Almost all of the large square covering nearly the whole northwestern part of North America on Map b represents consumption by the United States Treasury. Only a negligible portion represents industrial consumption in this country and in Canada. The consumption squares for the United Kingdom stand for consumption in arts and industries only; they do not represent the difference between the imports and the exports of silver, since they do not include accumulations in London by speculators. India's net consumption of silver was reduced in 1934 to an estimated mere 15,000,000 ounces. (It was about 94,500,000 ounces in 1930.) There was some mint consumption of silver by Hong Kong, Cuba, Mexico, etc. in 1934, for different reasons. But mint consumption abroad, in any case not important, has been affected adversely by the increase in price resulting from American Treasury purchases in 1935. As silver coins have gradually become more valuable as bullion than as currency, the tendency in various countries has been to discontinue using them. No attempt has been made on the maps to show all the mint consumption of silver throughout the world, though certain unofficial estimates for 1934 that were already available were included.

Map a is copied from a map accompanying the author's "The Silver Market," published by the U. S. Bureau of Foreign and Domestic Commerce in 1932 (*Trade Promotion Ser. No. 139*).

The data for Map b were prepared especially for the *Geographical Review*. The flow lines for 1934 are based partly on unpublished data compiled by the U. S. Department of Commerce and partly on *Accounts Relating to the Sea-Borne Trade and Navigation of British India* (India, Dept. of Commercial Intelligence and Statistics, Delhi, December, 1934, pp. 268–269, March, 1935, pp. 268–269) and *Monthly Returns of the Foreign Trade of China*, December, 1934 (China, The Maritime Customs, I.—Statistical Ser.: No. 8, Shanghai, 1935, p. 110). The production squares for 1934 are based on unpublished statistics compiled by the American Bureau of Metal Statistics (the 1934 mine-production figure for the United States is that of the Bureau of Mines); the consumption squares are based on estimates by Handy and Harman.

The currency maps of China (Maps c, d, and e) are from the Kemmerer Commission's report on the Chinese currency (The Project of Law for the Gradual Introduction of a Gold-Standard Currency System in China . . . Submitted to the Minister of Finance by the Commission of Financial Experts on November 11, 1929, China, Ministry of Industry, Commerce and Labor, Bur. of Industrial and Commercial Information, Shanghai, App. E, App. F, and App. G respectively). It is reported from China that in some areas fractional paper money has practically displaced small coins. As yet there are not enough data at hand to permit the preparation of comparable maps for 1935.

A FLIGHT TO CAPE CHIDLEY, 1935

Alexander Forbes

[With separate map, Pl. I, facing p. 56]

FIG. 1—Map of Labrador showing the area covered by the Cape Chidley sheet (Pl. I).

A flight from Boston to Cape Chidley and return was made in the summer of 1935 in connection with an aerial survey of northern Labrador begun in 1931 by an expedition sponsored by the American Geographical Society.[1]

The primary object in 1931 had been to carry out the field work necessary for testing the new method of producing a topographical map from oblique aerial photographs that has been developed by O. M. Miller of the American Geographical Society. The Labrador Peninsula from Nachvak Fiord north, an area of about 4000 square miles, was covered. The ground control, established by Mr. Miller, provided a skeleton on which to build the final structure of this map of northern Labrador.

In 1932 the Fairchild seaplane that had been used the year before was sent north. Photographing was continued southward, covering the Atlantic coast line from Nachvak to Port Manvers, a distance of about 160 miles, and overlapping the area north of Nain, which has been mapped by Wheeler.[2] Charles J. Hubbard, who had been a member of the 1931 expedition, sailed north from St. Anthony in the schooner *Zavorah*, which served as mother ship for the plane, and made an independent triangulation at Hebron as a ground control for this southern area.

Since then the work of constructing a map from the photographs has been progressing at the American Geographical Society, and the first of a series of topographic sheets accompanies this paper.[3]

OBJECTIVES OF FLIGHT OF 1935

The region had not been reconnoitered before the flights of 1931 and 1932, nor had we learned the best method of taking photographs for this new type of survey. It is not surprising, therefore, that the

[1] For a preliminary report see Alexander Forbes: Surveying in Northern Labrador, *Geogr. Rev.*, Vol. 22, 1932, pp. 30–60.

[2] E. P. Wheeler, 2nd: Journeys about Nain: Winter Hunting with the Labrador Eskimo, *Geogr. Rev.*, Vol. 20, 1930, pp. 454–468; *idem:* The Nain-Okak Section of Labrador, *ibid.*, Vol. 25, 1935, pp. 240–254.

[3] See Plate I and Appendixes, pp. 53–57 below.

ground was not completely covered, especially in regions such as the Torngat Mountains, where steep cliffs may conceal a mountain valley or the shore line of lake or fiord. Several gaps were found in the surveyed areas, and another flight for the purpose of photographing missing bits of inland shore line as well as some deep gorges among the high peaks of the Torngat Mountains was necessary if the map was to be complete. Indeed, a considerable tract of country between flight lines in the west half of the region north of Nachvak Fiord had been so remote from the camera in the previous series that much valuable detail had been lost, and a complete series from a new flight line through that area was greatly desired.

A somewhat different objective gave added reason for a flight north in 1935. Sir Wilfred Grenfell has called attention to the need of a safe harbor of refuge on the east side of the peninsula near Cape Chidley. A harbor, free from shoals, would be a boon to the grain steamers plying between Hudson Bay and Europe. The tides of Ungava Bay are so great (19 feet at Port Burwell) that a harbor on the Atlantic side of Cape Chidley, where the tidal range is much less, would be preferable.

In the summer of 1934 Commander MacMillan entered an excellent and probably hitherto unexplored harbor about seven miles south of Cape Chidley. To fly along the coast and examine the approaches to this and other harbors near Cape Chidley seemed to us worth while; for in those clear waters any shoal that could endanger a ship can be quickly and surely seen from an airplane.

Preparations for the Flight

It was estimated that, if enough gasoline for about six hours' flying could be delivered at Hebron and small quantities at Cartwright and Nain, it would be possible to dispense with a mother ship and make the expedition self-contained in a single seaplane. To do this and be prepared for all possible contingencies required a plane of large carrying capacity; for one must be equipped to make engine repairs or to journey a hundred miles back to a settlement, in the event of a hopeless breakdown. That means a pneumatic boat, camp gear, and food enough for two or three weeks.

The seaplane used in the previous expeditions was chartered for the flight. This plane could carry two men and a liberal supply of equipment. Charles J. Hubbard, whose familiarity with Labrador and with the plane and whose resourcefulness and skill at servicing an engine fitted him exceptionally well for the task, went as chief pilot and mechanic. The writer took charge of photography[4] and acted as reserve pilot.

[4] For the essential photography Dr. Richard U. Light generously lent us his Fairchild 5 x 7 camera; this was supplemented by a Leica, supplied with Dufaycolor as well as ordinary film.

FIG. 2—Looking up the northwest arm of Saglek Fiord. Aug. 6, 1935.

Cargo space is scarce on the Hudson's Bay Company ship *Fort Garry*, but she managed to deliver 150 gallons of gasoline for us at Hebron. Supplies were also sent in advance to Cartwright and Nain. At Hopedale several barrels of the gasoline donated for the first flight in 1931 were still on hand.

SAGLEK BAY AND NACHVAK FIORD

We set out from Boston on the afternoon of August 3 and reached Hebron, our last fueling point and our jumping-off-place, on the morning of August 6. Here we stayed five hours to refuel, clean spark plugs, and adjust valve clearances. We also arranged with the agent of the Hudson's Bay Company to send a motorboat in search of us if we failed to return in a fortnight.

At a quarter to six, with the sun still high in the sky, we took off for our flight into the northern wilderness. Saglek Bay is only a short distance north of Hebron, and with our heavy load it was all we could do to reach an altitude of 6000 feet by the time we arrived at a branching fiord that we wished to photograph. Here the problem was to record the shore line of the branches of the fiord, flanked by steep cliffs, with a minimum of deviation from our course and of photography. By passing the mouth of one branch and photographing up it and then passing beyond the head of the other branch and photographing down it, we covered both branches in two pictures (see Figs. 2

FIG. 3—Looking down the southwest arm of Saglek Fiord. Aug. 6, 1935.

and 3). The routine taking of pictures at regular intervals, suitable enough for some kinds of terrain, would probably have missed both branches.

From the head of this fiord we flew north at 7000 feet over a land of jumbled peaks and rivers, with but few lakes, until we came to the brink of the vast chasm that is Nachvak Fiord. Skirting its south edge, we flew westward, photographing missing portions of its shore line as far as the head of the fiord. There we glided steeply down a valley leading to the head of the fiord, into the turbulent air between the cliffs, skimmed over the short connecting stream, and landed on the waters of Nachvak Lake, where we made camp for the night under the shadow of the dark cliffs overlooking its north shore. From our camp seven waterfalls could be seen tumbling down sheer walls of rock that descend abruptly to the lake from the highest peaks in all Labrador—5000 feet and more.

The next morning, August 7, we flew the length of the lake and several miles on up the valley and then doubled back to the head of Nachvak Fiord to gain enough altitude for our pictures. Thence we flew northwest at 8000 feet until we were west of the mid-line of the peninsula, when we turned north and passed over a land of innumerable lakes to Port Burwell at the northeast corner of Ungava Bay. Here we landed and were hospitably received by the Hudson's Bay Company agent, who gave us lunch.

FIG. 4—McLelan Strait from the southeast. Aug. 7, 1935. Mt. Sir Donald on left of picture.

EXPLORATIONS NEAR CAPE CHIDLEY

In the afternoon we went up again, photographed missing portions of McLelan Strait (Grenfell Tickle), and then at a lower altitude examined the harbors and channels along the coast just south of Cape Chidley. Back and forth over this stretch of coast we flew, taking photographs and noting the location of shoals that the pictures might not reveal. Lady Job Harbor, southwest of the point of Cape Chidley, we found deep and free from shoals except for one close to shore, which our photographs have placed accurately on the map. The island of Cape Chidley is steep and bold on all sides. We flew around it and could see that deep water extends at least a mile in all directions seaward from its shores. The approach to the harbor discovered by Commander MacMillan is not so clear. A few shoals were found and their positions noted. It appeared that the entrance may be safely approached by following the coast south from Cape Chidley, keeping about a quarter of a mile off the headlands, and passing halfway between the shore and a visible cluster of reefs and islets 6 miles south of the cape. But a masthead lookout should be maintained in approaching this harbor. Still greater caution should be observed around the east entrance to McLelan Strait, for here numerous shoals were seen.

After climbing to a high altitude over Ryan's Bay we obtained pictures of the deep gorges in the "Four Peaks" and of the missing

FIG. 5—Cape Chidley from the north. Aug. 7, 1935. The cliffs here are between 1200 and 1600 feet high.

shore line of Kangalaksiorvik Fiord. Then, passing over our old base in Seaplane Cove, we headed straight for Hebron, and with our photographic work done—all but a few of the less important gaps filled in—we landed there at 6.18 p. m. (Newfoundland time), a little less than four days after our departure from Boston.

From Hebron we proceeded less hurriedly southward, making one digression inland to camp for a night on Cabot Lake, south of Nain. After this the weather became more unsettled, but still every day was fit for flying, and on August 14 we landed on Boston Harbor, only eleven days after our departure, thanks to the remarkable continuity of good weather with which we had been favored. Forty-five hours in all had been spent in the air.

APPENDIX I—NOTES ON THE CONSTRUCTION OF THE CAPE CHIDLEY SHEET

O. M. Miller

THE method employed in constructing the map of northernmost Labrador of which Sheet No. 1[1] is published in this number of the *Geographical Review* is very much the same as in ordinary ground surveying except that the measurements are made from aerial photographs in which the horizon appears. Each

[1] The remaining sheets of the series, together with a key map, will be issued at a later date by the American Geographical Society as part of a special publication.

photograph is considered as a survey station, and the first step is to determine what, at the moment of exposure, were the position of the air station, the height of the airplane, the tilt and direction of the camera axis, and the relation of the horizon line to the sides of the photograph. This resection process requires that three or more easily identified, already established points be imaged in the photograph. The method developed at the American Geographical Society[2] is a simple mathematical analysis of angular measurements extracted from the photograph in either a photogoniometer or a single-eyepiece oblique plotter devised by the writer.[3] When one photograph has been resected, all shore lines at sea level appearing in the photograph can be drawn on the map quickly and truthfully in the oblique plotter without the necessity of relying on the judgment of the individual who is making the map. When two or more photographs have been resected, more major control can be built up, more photographs can be resected, and finally a sufficient density of fixed points and height controls can be obtained by intersection in the plotter to enable the lake shore lines to be plotted and the topography delineated by sketched contours. As nearly all the topographical features can be studied in the photographs from various aspects at the same time, the topographical expression is likely to be more detailed and truthful than in the case of plane-table work on the ground. Considered solely in relation to aerial surveying, this first experimental sheet has convinced us that the method is a practical one in small-scale mapping. Especially is this so where something much better than a purely reconnaissance map is required but where weather conditions or time limitations in the field do not permit the establishment of a dense network of ground control.

Specific Details

The Cape Chidley sheet will probably prove to have presented the most difficult problems of the series. The terrain over a large part of the area mapped is extremely broken and irregular. The ground control established in 1931 consisted, as far as the particular area is concerned, of one rather poor intersection on Mt. Sir Donald and a tangent ray to Cape Chidley from occupied stations in the neighborhood of Cape Kakkiviak about 37 kilometers southeast of Mt. Sir Donald. The major control from which most of the air stations were resected was built up from a few air stations in the northwest that had been resected from the denser control to the south beyond the limits of the present sheet. These stations were checked for tilt and relative position to one another by intersections of sea-level points in the foreground. Although the 1931 photography by S. O. Bonnick was excellent, conditions, including the weather, did not permit a careful reconnaissance before the survey flights. This, linked with our inexperience in the method, resulted in a far from ideal arrangement of the air stations.

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[2] The resection process makes use of a differential formula that, in most cases, arrives at a sufficiently exact determination of tilt and swing after one approximation. It is a logical development of an approximate method of resection described by the present writer in "Planetabling from the Air: An Approximate Method of Plotting from Oblique Aerial Photographs," *Geogr. Rev.*, Vol. 21, 1931, pp. 201–212, and "Additional Notes on 'Planetabling from the Air,' " *ibid.*, pp. 660–662; the mathematical development of the differential formula was published by him under the title "Experiments at the American Geographical Society in Small Scale Mapping from 'High Obliques,' " *News Notes of the Amer. Soc. of Photogrammetry*, Vol. 1, 1935, No. 5, pp. 25–34. Another, somewhat similar method of resection of high obliques has been devised by Captain D. R. Crone, R.E. (Survey of India Handbook of Topography, Chapter 12, Air Surveys (Provisional Edition), Dehra Dun, 1933, Addendum No. 4, Oct., 1934).

[3] These two instruments were constructed from specifications provided by the writer by the Mann Instrument Co. of Cambridge, Mass., and their detail mechanical designing was undertaken by Mr. David W. Mann and his assistant, Mr. K. W. Harper. For brief descriptions of the instruments see *News Notes, loc. cit.* The single-eyepiece plotter was more fully described by the writer in "An Optical Device to Aid in Mapping from Photographs," *Journ. Optical Soc. of America*, Vol. 25, 1935, pp. 185–189. Another instrument for plotting maps from high oblique photographs has recently been developed in Canada (E. L. M. Burns and R. H. Field: A Plotter for High Oblique Air Photographs, *Canadian Journ. of Research*, Vol. 13, 1935, Sect. A, pp. 22–33).

In the 1931 series of photographs there were four flight lines covering the Cape Chidley sheet. One was parallel to the east coast and offshore about six kilometers, and a second was parallel to the first but inland about 14 kilometers. The height of flight in both averaged about 2300 meters and the average tilt of the camera axis below the horizon about 8°. The third flight line was off the west coast, the distance to the shore ranging from about 10 kilometers in the south to 5 kilometers in the north. The height of flight was about 1600 meters and the average tilt about 7°. The fourth flight line practically duplicated the second until it reached the southern part of the area. The photographs on this flight were taken almost at sunset. Certain areas in the center of the sheet were too remote to be plotted in detail from the 1931 photographs depicting them, but fortunately the excellent series of photographs taken in 1935 by Dr. Forbes was available for filling in most of the gaps.

In all, 45 photographs were accurately resected, 14 more were used for supplementary sketching of detail in the plotter, and an additional 55 were examined as aids to the sketching of detail but measurements were not taken on them. Not counting the third group of photographs, since these would not have been necessary if the original scheme of photography had been more carefully worked out, the ratio of photographs to square kilometers mapped was 1 to 27. Fifty-four points were established trigonometrically as major control, and 837 minor-control points were established in position and height by graphic intersection in the plotting instrument. In addition, numerous tangent rays and the outlines of the sea coast line and lakes were automatically drawn in the plotter except for a small area in the southeast where the Canadian grid method was used.

Surprisingly little difficulty was experienced in identifying control obtained from the 1931 series in the 1935 photographs. Even the snow patches maintained their positions and shapes approximately.

Speed and Accuracy of Work

As a test of the speed of working the method, it is hardly fair to take the first experimental sheet as an example. Nevertheless, an indication can be gathered from the following. The southeastern part of the sheet, about one-sixth of the total area mapped, was controlled and mapped by Mr. Wood and the writer during the months of October and November, 1934, before the plotter had been constructed. The coast line was plotted by the Canadian grid method, and the rays to intersected points were plotted with a vernier protractor after the directions had been measured in the photogoniometer. The heights were computed from measured distances on the plotting sheet and vertical angles measured in the photogoniometer. It is conservative to say that this part of the map took two men six working weeks to complete. The control for the remaining portion of the sheet was started by Mr. Hitchcock and the writer at the end of July, 1935, and the entire sheet was compiled by the first week in November. From about the end of September on Mr. Wood gave most of his time to assisting in the work, and Mr. F. M. Mann also gave valuable assistance for a few weeks. In all of the latter part of the work use was made of the single-eyepiece plotter for plotting coast lines and for making intersections and obtaining heights. By a rough estimation from the foregoing, the whole process of providing control and plotting detail can be summarized as follows: first portion of sheet, about 264 square kilometers, completed at the rate of 22 square kilometers per man per working week; second portion of sheet, about 1336 square kilometers, completed at the rate of 42 square kilometers per man per working week. In terms of paper covered on the scale of compilation (1 : 50,000), these figures work out at 88 square centimeters and 168 square centimeters respectively. The greatest consumer of time was undoubtedly the selection and identification of suitable control.

The instruments employed give an accuracy in measurements of angles of about

1′ of arc. Owing, however, to the absence of well established ground control in the area covered by the sheet, no absolute check on the accuracy of the survey as a whole is available. The comparison between the position of the Canadian astronomical station at Port Burwell as established by the Dominion Observatory in 1928 and its position as computed through the aerial triangulation from the astronomical station established by the Grenfell-Forbes expedition in 1931 is not a valid check, since there is no way of assessing the accuracy of the astronomical positions in themselves. However, the comparison is made for what it is worth. Between the origin of our survey at latitude 59° 20′ 34″ N., longitude 63° 49′ 07″ W., and Port Burwell, latitude 60° 24.7′ N., longitude 64° 52′ W., the computed spherical rectangular coördinates are 119,650 N. and 57,750 W. and the plotted plane rectangular coördinates 119,675 N. and 56,900 W. This merely indicates the possibility of a scale difference of 1 in 385 and a difference in bearings of about 20′. As far as the relative positions of points within the area of the sheet are concerned, the three-point intersections obtained would indicate that most of the positions are not in error by more than 50 meters, or 0.5 millimeters on the map. Height checks on intersected points would indicate on the whole a probable error of less than 10 meters, which is satisfactory, inasmuch as no established datum level existed in the area and there was a considerable tidal range, especially on the west coast.

Only a few place names have been entered on the map, and some of these should be regarded as provisional. Up to now very little has been known of the region, and the exact identification of certain named features is difficult to determine in comparing the present map with those that have been published previously. Reference has been made, however, to charts 404 and 405 of the Canadian Hydrographic Service, editions of 1930 and 1931 respectively, also to Sir Wilfred Grenfell's sketch maps, particularly the one appearing on page 56 in his book "Labrador" (New York, 1913). Mention should also be made of Bernhard Hantzsch's map of northern Labrador appearing opposite page 706 of *Mitteilungen des Vereins für Erdkunde zu Dresden*, Volume 2 (No. 7, 1913). Captain F. Anderson, the Canadian Hydrographer, has kindly given us additional information. No attempt is made to avoid duplication of Eskimo and English generic terms in individual place names.

APPENDIX II—PHYSIOGRAPHY OF THE CAPE CHIDLEY SHEET

Charles B. Hitchcock

PRACTICALLY no geologic field work has been carried on in the pre-Cambrian complex of the region shown on the Cape Chidley sheet. Some idea of the nature of the bedrock has been gained from a study of the photographs of the region. In the east the rocks are definitely gneissic or schistose and show a marked foliation trending north-south[1] and standing almost vertically. This foliation is less apparent in the southern part of the sheet. In the west the bedrock appears highly confused, and no distinct trend is apparent from the photographs. We have some idea of the rocks in the western part from a single observation by A. P. Low near Port Burwell. He describes the bedrock there as "a highly contorted, fine to medium-grained, red hornblende-gneiss cut by large dykes of dark-green diabase."[2] Elsewhere

[1] Strikes ranging roughly from 5° W. to 10° E. have been noted in this area to the north of McLelan Strait and around 10°–15° E. in the southern part. For comparison with structural trends farther south see the sketch map showing bedrock geology along the northeast coast of Labrador, Plate 11 in R. A. Daly: The Geology of the Northeast Coast of Labrador, *Bull. Museum of Comp. Zoöl. at Harvard College*, Vol. 38 (Geol. Ser., Vol. 5), 1900–1903, pp. 203–270.

[2] Report on Explorations in the Laborador Peninsula . . . in 1892–93–94–95, *Canada Geol. Survey Ann. Rept.*, Vol. 8 (N.S.), 1895, Report L, p. 222.

AMERICAN GEOGRAPHICAL SOCIETY

MAP OF NORTHERNMOST LABRADOR 1:100,000

constructed at the AMERICAN GEOGRAPHICAL SOCIETY from the oblique aerial surveys of the FORBES-GRENFELL EXPEDITION of 1931 and the FORBES EXPEDITION of 1935

70W. 65°00' 60W. 64°45' 50W. 40W. 64°30'

60° 30'

60° 15'

G R A Y S T R A I T

To Button Is. (7.5 km. approx.)

To Knight Islands (4.5 km. approx.)

K I L L I N E K I S L A N D

PORT BURWELL

CAPE WILLIAM SMITH

U N G A V A B A Y

TUNNUSSAKSUK INLET

McLELAN STRAIT (GRENFELL TICKLE)

Lady Job Harbor

MOUNT SIR DONALD 570

J O K S U T I N L

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Lith. A. Hoen & Co., Inc.

Leader of expeditions, Alexander Forbes. In charge of survey operations, O. M. Miller. Assistants in map construction from photographs, Walter A. Wood and Charles B. Hitchcock. Topography edited by Charles B. Hitchcock. Methods and instruments for constructing map developed by O. M. Miller at the American Geographical Society. Measurements from photographs made in specially designed photogoniometer and single-eyepiece oblique plotter; the latter was also used for plotting coast line and obtaining intersections and heights of minor control points.

Contour interval 50 meters

Scale 1 ½ 0 5 10 15 Kilometers

1 ½ 0 1 2 3 4 5 6 7 8 9 Statute miles

OF NORTHERNMOST LABRADOR 1:100,000

constructed at the AMERICAN GEOGRAPHICAL SOCIETY from the oblique aerial surveys of the FORBES-GRENFELL EXPEDITION of 1931 and the FORBES EXPEDITION of 1935

SHEET No 1: CAPE CHIDLEY

64°45' 50W. 40W. 64°30' 30W. 64°15' 20W. 60°30' 60°15'

S T R A I T

To Button Is (7.5 km. approx.)

To Knight Islands (4.5 km. approx.)

K I L L I N E K

I S L A N D

CAPE CHIDLEY

401

327

382

A T L A N T I C

O C E A N

Lady Job Harbor

TUNNUSSAKSUK INLET

McLELAN STRAIT (GRENFELL TICKLE)

MOUNT SIR DONALD

376

J O K S U T I N L E T

HOME I.

Contour interval 50 meters

0 1 2 3 4 5 6 7 8 9 Statute miles

0 5 10 15 Kilometers

The Geographical Review. Vol. XXVI, No. 1, 1936, Pl. I.

Map projection, Cessini-Soldner (Rectangular Spheroidal) with origin at latitude 59°20'34" N., longitude 63°49'07" W. Positions of control points plotted by plane rectangular coordinates from the same origin. Inner marginal divisions show minutes of latitude and longitude. Outer marginal divisions show kilometers from origin of the survey. Broken lines on map indicate detail insufficiently depicted in photographs. Stippling indicates probable shoal areas, but it must not be presumed that all such areas are shown, since some were probably not discernible in the photographs.

UNIV. OF MICH.

he notes concerning this type of rock that "sometimes over large areas the foliation is obscure, and the rock then approaches a true hornblende-granite."[3] The difference in the character of the rocks of the eastern and western parts is very striking in the photographs.

The surface of the elevated part of the sheet suggests a warped peneplane extending from the south border to the northern tip of land.[4] This drops off abruptly to the west to meet a lower peneplaned surface that slopes gently westward and northwestward and in the southwestern part of the sheet is covered by the waters of Ungava Bay. On the east coast the high country has in places a relatively low coastal area and is fringed by islands. A more complete explanation for these surfaces will be afforded as mapping covers a broader area and a more detailed record of the physical features is made.

In the northeastern part, where strong north-south foliation is developed, conspicuous north-south valleys as well as related coastal embayments and islands elongated in the same direction suggest subsequent valleys developed in belts of weak rock. In the south and southeast, where the foliation is less apparent, valleys running parallel to it are less conspicuous. In the western part, where good foliation is absent, valleys of a north-south trend are also absent. Other valley trends cutting at an angle to the foliation are immediately apparent on the map. The parallelism of these different groups of valleys is evident. Their formation may have been governed by weathering, fluvial action, and glacial scour and plucking along systems of joint fractures or fault lines. This outstanding series of crisscrossing valleys gives an almost geometric pattern to the map and affords an interesting comparison with similar areas in Norway between Trondheim Fiord and Nord Fiord.

The entire region appears to have been covered by continental ice. Low remarked that "near Port Burwell, just inside Cape Chidley, . . . the lower hills only are glaciated, and the striæ run N. 10° E."[5] The present writer has not found an adequate explanation of Low's reasons for excluding the higher parts of the area from glaciation. The rock surface is everywhere bare or but thinly veneered, and the summits and gentler slopes are dotted with lakes of different sizes, many of which can be seen to lie entirely within rock basins. The northerly trend of striæ recorded at Port Burwell suggests that the ice moved diagonally across the western part of the depression that now forms the McLelan Strait. Here, and probably in other places as well, where the movement was across the trend of an existing valley, modification of the valley by the continental ice is less apparent. The western part of McLelan Strait does not have the marked characteristics of a fiord, nor have most of the reëntrants of the west coast. Soundings in the strait[6] show that even in its narrower parts it is deep (average depth 90 to 120 meters), V-shaped, and does not bear the characteristics of a vigorously ice-eroded valley. Joksut Inlet and the embayment directly to its south, however, suggest true fiords. The shapes of some gently molded valleys of the upland, as well as of more precipitous slopes, may be attributed to ice modification.

The shore line represents an extremely youthful stage of submergence. Whereas

[3] *Ibid.*, p. 198.

[4] There are numerous references in literature to peneplanation on the Labrador peninsula. H. C. Cooke (Studies of the Physiography of the Canadian Shield: I, Mature Valleys of the Labrador Peninsula, *Trans. Royal Soc. of Canada*, Ser. 3, Vol. 23, Sect. 4, 1929, pp. 91–120) remarks that "the old peneplain surface of the Labrador peninsula has been unequally warped upward, some parts attaining a high elevation. . . . At the northeast corner of Labrador, the plateau is locally warped sharply upwards to form the Torngats" (p. 93). N. E. Odell (The Mountains of Northern Labrador, *Geogr. Journ.*, Vol. 82, 1933, pp. 193–210 and 315–325) describes a summit surface in the higher Torngat Mountains to the south of the Cape Chidley sheet. He suggests that "instead of this erosion-surface being prima facie a stream-formed peneplain of the more usual kind, its fluvial character has in all probability been sufficiently modified by overriding continental ice from the interior as to warrant its designation as a glacial peneplain" (p. 209).

[5] *Op. cit.*, p. 202.

[6] W. T. Grenfell and others: Labrador, the Country and the People, New York, 1913, p. 56

some of the larger inlets of the sea have fiord characteristics, most of them are more typical of a ria shore line. The imposing cliffs of the east coast at first glance suggest wave cutting. Examination of the photographs shows that these cliffs represent parts of continuous sloping surfaces connected directly with the topography of the upland and readily explainable by processes of subaerial denudation and glacial modification. Equally imposing cliffs are developed in the lee of protecting islands and in the interior. The tiny crenulations of the shore line have not as yet been worn back by the waves. Small cliffs—apparently attributable to the direct action of waves—which in places are developed at the base of the larger cliffs as well as along the more subdued shore line, are relatively insignificant. In fact, the work of the sea has been carried on at its present level to such a small degree that beaches, bars, and other depositional shore features have barely had a chance to form. Johnson has observed similarly insignificant wave action along the shore of Acadia and New England and has discussed it in detail.[7]

Throughout the west half of the map there are many irregularities in the relief that find no expression in the 50-meter contour interval. There is a suggestion that the general degree of slope of the land surface toward Ungava Bay is reflected by these irregularities in the island pattern. Where the slope is gentle, as in the southwestern part of the sheet, the small irregularities appear as a broad fringe of small islands. From the photographs the sea would appear to be shallow, if not actually characterized by shoal water, at considerable distances from the shore. Where the slope of the land is greater, as on Killinek Island to the northwest, the fringe of small islands is extremely narrow, and the coast is marked rather by a small number of large islands.

[7] Douglas Johnson: The New England-Acadian Shoreline, New York and London, 1925.

VEGETATION ZONES IN THE CAUCASUS

William Seifriz
University of Pennsylvania

VEGETATION zones as determined by altitude are well marked in certain regions, especially on tropical mountains, but elsewhere they so merge into one another or are so influenced by exposure, precipitation, and glaciation that they cannot be sharply delimited. The latter condition is more typical of the Caucasus. However, altitude is always a factor to be reckoned with, and, in

FIG. 1—Panorama of Tskhra-Tskharo, Minor Caucasus, showing altitudinal plant zones: 1, lower fields with wild apple and pear; 2, deciduous forest; 3, tree line of birch; 4, rhododendron thickets; 5, high-grass subalpine fields; 6, alpine pastures.

spite of exceptions and confusions, the zone is a convenient geographic unit by which to characterize plant distribution on mountain slopes.

The Caucasus (Fig. 2) offers every conceivable problem in plant geography.[1] South of the main range lie the semideserts of Tiflis, the subtropical shores of the Black Sea, the luxuriant forests and fields of Svanetia, and, in the Minor Caucasus (or Transcaucasus), the garden spots of Borzhom and Bakuriani and the parched hills along the Armenian border. The north slopes of the main range, which fall away to the flat expanses of the Russian steppes, are more uniform among themselves but differ wholly from anything to be found on the south side. From Mt. Kazbek on the east to Mt. Elbrus on the west, these slopes are rocky and precipitous, with grass fields insufficient for grazing. The southern Caucasus supplies the northern with hay; but although the south surpasses the north in wealth of forests and pastures, the north has some of the finest natural flower gardens in the world.

In the Caucasus there is an extraordinary variety of plants. Many of these are endemic, as is evident from the frequent occurrence of the

[1] For a more detailed study see the writer's "Sketches of the Vegetation of Some Southern Provinces of Soviet Russia," II, III, VI, and VII, *Journ. of Ecology*, Vol. 19, 1931, pp. 372–382; Vol. 20, 1932, pp. 53–68; Vol. 23, 1935, pp. 140–160.

specific term *caucasica* in botanical nomenclature. Plants, like people, seem to have stopped here in their migratory journeys (nineteen different languages are spoken). The distinctive plant life is due primarily to the high barrier formed by the mountains between regions of wholly different climate.

FIG. 2—Location map of the Caucasus. Scale approximately 1 : 8,000,000

VEGETATION ZONES OF THE MAIN RANGE

The Georgian Military Way (Fig. 2) from Ordzhonikidze (Vladikavkaz) to Tiflis passes through the renowned Daryal Gorge. A journey along this route provides an opportunity for studying the typical vegetation zones of the main range. North of Ordzhonikidze spread the great steppes, which, where not in cultivation, support that most characteristic of all steppe plants, artemisia. The best-known of the Russian artemisias is *A. absinthium* (*A. tridentata* is the sagebrush of southwestern North America).

Where the steppes rise to meet the slopes of the lower foothills and forestation has left open areas, a number of small plants find a home and convert the steppe-forest transitional subzone into a floristically attractive region. Here, at 2400 feet, the dioecious shrub *Hippophaë rhamnoides* grows in extraordinary abundance, and herbaceous plants with showy flowers make their first appearance, though they are more abundant in the slightly higher and cooler ravines of the foothills.

The lowland forest, a herbaceous woodland in the main, is entered at an altitude of 2500 feet, near the former village of Balta. The black poplar (*Populus nigra*), monarch among the trees, though not abundant, has a wide distribution in the Caucasus. Its close relative *P. pyramidalis* is more numerous and gives to the landscape something

of the appearance of southern France. Abundant also are the willow (*Salix alba*), common along the banks, the locust (*Robinia pseudo-acacia*), and the wild apple (*Pyrus Malus*). Most prolific of all is the hawthorn (*Crataegus melanocarpa*), which grows into sturdy trees five meters in height and is very characteristic of the foothills.

FIG. 3—Tree line of birch on the moraines of the Bash-Kara Glacier of the main Caucasus range in the valley of the Adyl-su.

Away from the road and well within the denser lowland forest there occurs an association of deciduous trees consisting chiefly of the linden (*Tilia caucasica*), beech (*Fagus orientalis*), elm (*Ulmus nitens*), and oak (*Quercus iberica*).

On emerging from the lowland forest one enters a deep valley surrounded by massive hills (ca. 3000 feet) devoid of all forms of arboreal vegetation. These bald mountains, some of them perfect cones, make a striking panorama. Whether they were once forested and later denuded (as botanists maintain) or have never been covered with trees (as the natives believe), it is impossible to say. They support chiefly the grasses, poa, festuca, and brome and, along the stream banks, a wealth of richly colored flowers, including *Althaea ficifolia*, *A. rosea*, *Inula helenium*, *Asparagus verticillatus*, and *Physalis alkekengi*. A lower herbaceous zone of this kind is found nowhere else in the Caucasus.

Eighteen miles from Ordzhonikidze, near the village of Lars, the upper, primarily evergreen, forest begins at an altitude of about 4000 feet. The dominant plant is a form of the European pine (*Pinus sylvestris*) and has been named *P. caucasica* and *P. hamata*. In precarious positions at higher altitudes, or often because of another kind of soil, grows a scrubby form, the mountain pine, *Pinus montana* (*P. sylvestris* var. *alpina*). The species, taxonomically doubtful, is

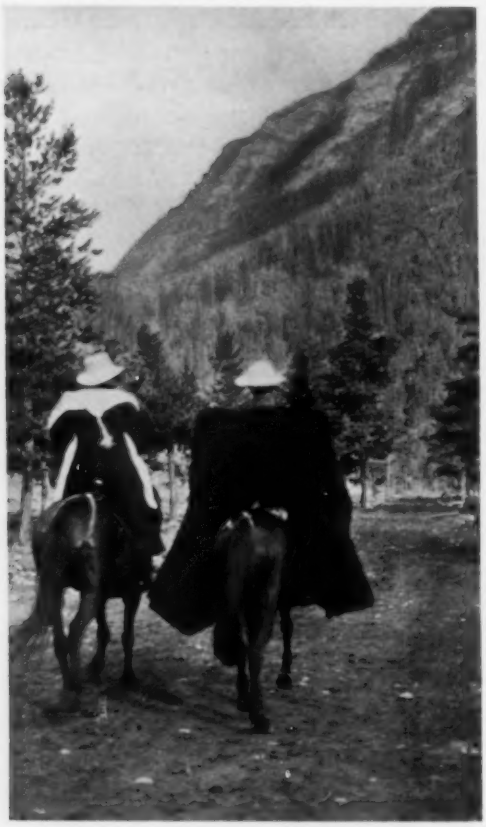

FIG. 4—Pine forest on south-facing slope at Tegenekli, Balkaria.

characterized by its soil preference, since the *montana* form grows on granite. Three species of juniper and a yew (*Taxus baccata*) complete the list of conifers along the Georgian Military Way.

The deep Daryal Gorge is a truly awe-inspiring canyon. Vegetation becomes sparse: mountain pines perch upon ledges here and there, and an occasional alpine flower clinging to a crevice is a forerunner of the flora of still higher altitudes. A truncated cone of rock, crowned by the ruins of a castle credited to the legendary Queen Tamara, marks the upper, or south, end of the gorge and the limit of the evergreen forests. Several species of deciduous trees, particularly the birch (*Betula pubescens*) and the rowan (*Sorbus aucuparia*), climb higher than the pine and form the tree line at 7000 feet. Elsewhere in the Caucasus the pine ascends to tree line on slopes of southern exposure, while the birch is sharply restricted to northern slopes. An occasional maple (*Acer Trautvetteri*) and a group of mountain poplars (*Populus tremula*), protected by a former monastery, are indications of the presence in this zone of trees that in other parts of the Caucasus are abundant and highly typical.

In valleys leading off from the Georgian Military Way at Kazbek and the smaller village of Gvilety herbaceous plants flourish luxuriantly in subalpine pastures at altitudes of about 6000 feet. Few gardens equal the profusion of color of the Caucasian subalpine vegetation. *Scabiosa caucasica* is queen among the flowers. Other conspicuous high-grass plants are the aconites (e.g. *Aconitum caucasicum*), poppies, gentians (e.g. *Gentiana caucasica*), the large yellow-flowered inulas, and the delightful aster-like pyrethrum.

The high alpine fields of the Caucasus at about 8000 feet take two forms, pasture and tundra (high moor). Belonging typically to the

tundra but constituting a community of their own are large, scrubby patches of rhododendrons, azaleas, and daphnes. The alpine pastures are much like those of the Alps, with similar genera dominating. In addition to the grasses (e.g. *Poa alpina*), the geranium (*G. pasterus*) is particularly abundant in certain localities; typical also are *Alchemilla sericea*, *Myosotis alpestris*, and *Saxifraga sibirica*. In moist depressions luxuriant growths of *Crocus flavus* occur up to 10,000 feet, and the autumn crocus (*Colchicum autumnale*) may also be found.

FIG. 5—Birch forest on north-facing slope, valley of the Uzengi, Balkaria.

MINOR (SOUTHERN) CAUCASUS

The Minor Caucasus lie in Georgia and along the border of Armenia. Less rugged than the main range, they offer some unusually delightful regions for rest and phytogeographical study. The forests of Borzhom are renowned. At Bakuriani an exceedingly pleasing valley presents many problems of ecological interest, especially that of the distribution of the pine. The pine is sharply restricted to south-facing slopes both here and in Balkaria (northern Caucasus). On the knoll Mucheri, near Bakuriani, an east-west line may be drawn down the middle of the east slope so that to the south of this line there is an almost pure stand of pine while to the north there is but a single pine tree.

The pine cannot stand competition but tolerates great dryness; consequently where precipitation is low or the drying effect of the sun pronounced it finds little competition and does well. These factors put it on the southern slopes in the Caucasus. In Armenia, on the other hand, it is found on northern slopes. North-facing slopes of the Caucasus have enough moisture for all forms of vegetation; the pine, therefore, is driven out by competition. The south-facing slopes have

insufficient rainfall for most plants but enough for pine. In Armenia the north-facing slopes are wet enough for pine but for little else; therefore, having no competition, the pine does well there. The south-facing slopes are too dry for any form of arboreal life. The minimum annual precipitation necessary for pine is 350 millimeters and for other trees 500 millimeters.

Altitudinal zones of vegetation are unusually well marked in the vicinity of Bakuriani. On the slopes of Tskhra-Tskharo (Fig. 1) one passes from lower pastures with wild apple, pear, and cherry up through deciduous forests of beech and elm on north-facing slopes (pine and spruce on south-facing slopes) into an upper deciduous forest of maple and then into the birch and rowan woods that form the tree line at 7000 feet. Subalpine fields follow with gentians, campanulas, primulas, geraniums, aconites, and poppies. As the summit is approached, large thickets of rhododendron and vaccinium cover the more precipitous slopes just below the ridge (Fig. 1). On the top a true alpine flora flourishes but under somewhat rigorous conditions. The cold wind-swept summit of Tskhra-Tskharo (8000 feet) supports the delightful *Campanula tridentata*, with its one large flower, low compact rosette of leaves, and taproot so characteristic of alpine plant life.

Balkaria

Few regions offer more to the botanist, the geographer, and the alpinist than does Balkaria (Fig. 2). The scenery is superb (Fig. 3), and the province has the honor of including Mt. Elbrus, the highest summit in Europe (18,470 feet). Problems in plant distribution are many. The sharp restriction of the pine to south-facing slopes is as well defined here as in the Minor Caucasus. The more luxuriantly forested northern slopes are covered chiefly with beech at lower and birch at higher altitudes, and this is true of the Caucasus in general. So pronounced is this restriction that the same mountain may have almost pure stands of pine on the south (Fig. 4) and of birch on the north (Fig. 5).

Tree-line studies are especially interesting in Balkaria. Here the high forests traverse the glacial moraines in many places (Fig. 3); the alpine and subalpine zones are thus eliminated, and the tree line is forced down to and below 7000 feet. On other slopes where glaciers are absent the tree line rises to a maximum of 8000 feet.

Tundra makes its appearance at 9000 to 10,000 feet where conditions are sufficiently severe, as on Mt. Elbrus. On the plateau known as Krugozor, where one of the glaciers of Elbrus ends its downward plunge, tundra forms (including the woody *Empetrum nigrum* and *Vaccinium vitis idaea*) intermingle with alpine herbaceous plants (*Aster alpinus*, *Antennaria dioica*, and *Minuartia caucasica*).

FIG. 6—Valley of the Ingur, Svanetia. Slopes covered with fir and spruce.

SVANETIA

The valley of Svanetia (Fig. 2) combines the tranquil beauty of a New England meadow with the awe-inspiring grandeur of snow-covered peaks. The province is part of the "Republic" of Georgia and lies immediately south of the main Caucasus ridge. On entering it from the north by the Donguz-Orun Pass, one leaves the overwhelming rocky pinnacles and ice sheets of the northern Caucasus and descends rapidly into a pastoral country (Fig. 6).

The forests here differ in several respects from those of the northern Caucasus. The fir (*Abies Nordmanniana*), lacking in the northern Caucasus and scarce in the Minor Caucasus, grows to great size. With

FIG. 7—A pure stand of *Populus tremula* at Tavrari, Svanetia.

it occurs the spruce (*Picea orientalis*), which is also absent in the northern Caucasus but common in the Minor Caucasus. Deciduous trees are many; they include all the genera so far mentioned and numerous others, notably oaks, of which there are three species. The dominant deciduous tree of the mountain slopes is the trembling aspen (*Populus tremula*), which reaches great size and where occurring in pure stands is a prominent feature of the landscape (Fig. 7). The alpine zone takes the form of pasture or tundra. In the higher valleys of the main range north of Mestiya one finds an association of plants typical of Arctic moors. A small community, covering not more than several square yards, contained the following typically Arctic forms: *Linnaea borealis*, *Pyrola secunda*, *Empetrum nigrum*, and the widespread moor heath *Vaccinium vitis idaea*. Altitude gives these plants here in latitude 42° the climate that they have at sea level in latitude 69°.

The Shores of the Black Sea

The coastal fringe of the Black Sea is an entirely different vegetational region. This is the Riviera of Russia. Grapes are grown extensively; ripe figs are common in the markets; the ailanthus and the leguminous tree albizzia are reminders of the Near East. Junipers are represented by five species, *Juniperus excelsa* being the most abundant. Oaks (*Quercus pubescens*), maples (*Acer campestre*), the hornbeam (*Carpinus orientalis*), the ash (*Fraxinus excelsior*), and the arbutus tree (*Arbutus andrachne*) are common where conditions are favorable.

PROBLEMS OF THE NILE VALLEY*

K. S. Sandford

FOR some years the Oriental Institute of the University of Chicago has maintained an investigation of the late-Tertiary and Quaternary deposits of the Nile and its tributaries, the results of which are now appearing in a series of volumes.[1] An outline of progress may, therefore, be not unwelcome at this juncture.

For our purposes we may begin the history of the Nile Valley with Miocene time, when the most striking changes in topography probably took place. A series of gentle north-south folds was created, which was crossed by more acute folds and fault belts of about east-northeast trend. These have been analyzed and described by Dr. W. F. Hume.[2] In his opinion—based on more than 30 years' official work in Egypt—the Nile was established in one of the north-south synclines, in which it remains throughout the greater part of its course in Egypt (Fig. 1). Dr. Hume's work, the researches of Dr. John Ball, and the early surveys by H. J. L. Beadnell have displaced the theory that the Nile Valley is a rift, and there is a mass of recent detailed corroborative evidence.

In Mio-Pliocene (Pontic) time there was an uplift of the northern part of the Nile basin and the adjoining plains of Eocene limestone: the river and its Egyptian tributaries cut their valleys to depths as yet unfathomed—more than 35 meters in Upper and Middle Egypt and 80 meters near Cairo (below the present flood plain).

The Pliocene period saw this movement reversed, and the valley was flooded to about 200 meters above present sea level. Both of these movements have long been known, but the recent studies of the Oriental Institute have provided detailed and precise information. It has been established, for example, that the valley was flooded as a unit, not in a series of basins. The work just published[3] also attempts

*"Two outstanding problems in the career of prehistoric man have long awaited solution. One of these is the genetic and chronological correlation of the remains of prehistoric man in Africa with similar remains, geologically dated, in Europe. The same problem exists as between Western Asia and Europe. The second is the correlation of the enormously ancient—presumably very early Paleolithic—remains on the plateau of Northeast Africa with the earliest stages of human development on the alluvial floor of the Nile Valley."—J. H. Breasted: The Oriental Institute (The University of Chicago Survey, Vol. 12), Chicago, 1933, p. 73. Mr. Sandford's summary shows what progress has been made with these problems in recent years.—EDIT. NOTE.

[1] Prehistoric Survey of Egypt and Western Asia: Vol. 1, Paleolithic Man and the Nile-Faiyum Divide, by K. S. Sandford and W. J. Arkell (Univ. of Chicago, Oriental Inst. Publs., Vol. 10), 1929; Vol. 2, Paleolithic Man and the Nile Valley in Nubia and Upper Egypt, by K. S. Sandford and W. J. Arkell (*ibid.*, Vol. 17), 1933; Vol. 3, Paleolithic Man and the Nile Valley in Upper and Middle Egypt, by K. S. Sandford (*ibid.*, Vol. 18), 1934. For a general account see K. S. Sandford: Recent Developments in the Study of Paleolithic Man in Egypt, *Amer. Journ. of Semitic Languages and Literatures*, Vol. 48, 1931–1932, pp. 170–183.

[2] The Significance of Folding and Faulting in the Orography of Egypt and Sinai, *Rept. of Proc.* [12th] *Internatl. Geogr. Congr., Cambridge, 1928*, Cambridge, 1930, pp. 207–216.

[3] "Prehistoric Survey," Vol. 3.

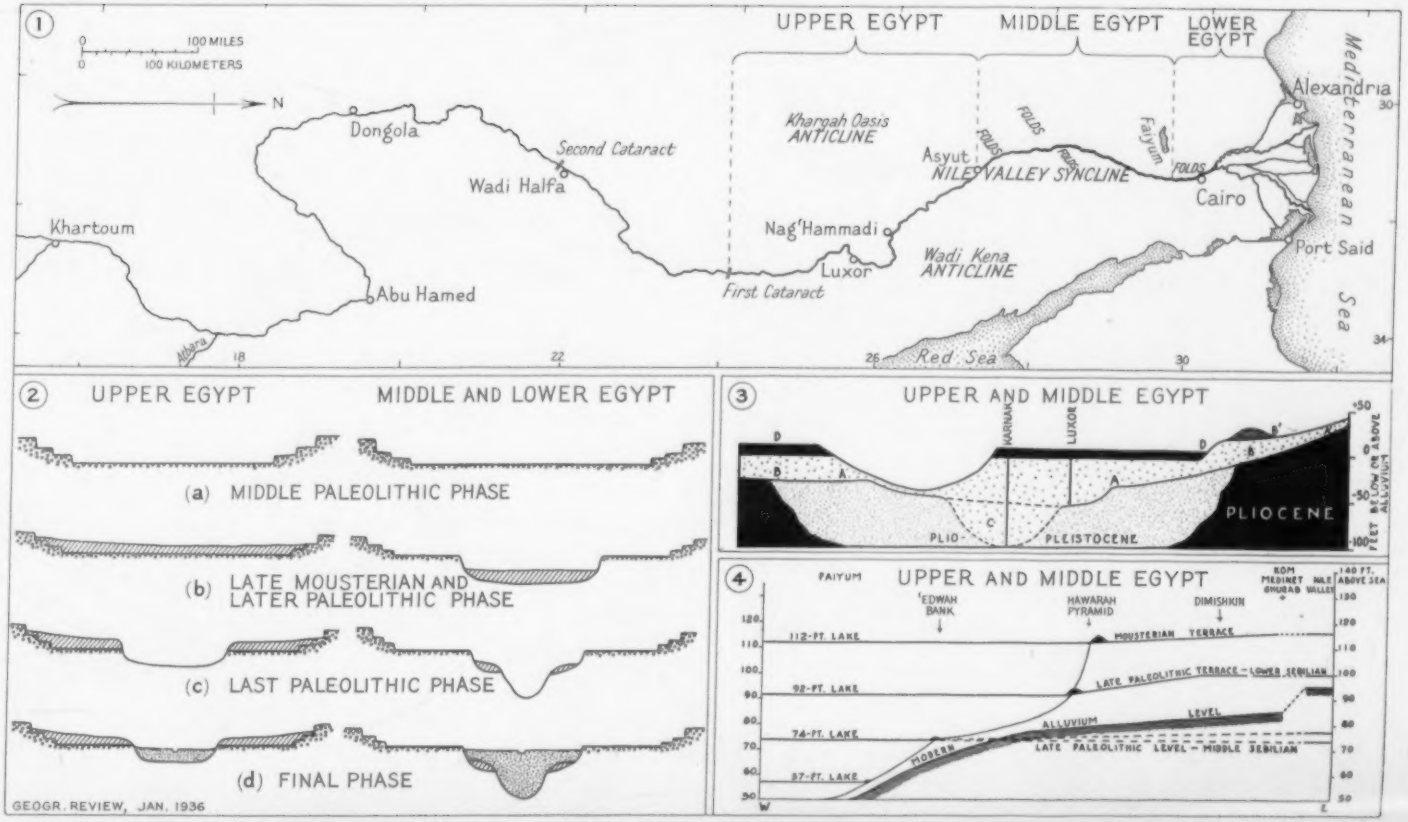

FIG. 1—Map of the course of the Nile from Khartoum to the Mediterranean. Scale 1 : 10,500,000.
FIGS. 2, 3, and 4—Cross sections of the Nile Valley in Egypt (2 and 3) and from the Nile to Faiyum (4). For explanation see note at foot of opposite page.

to show the detail of certain oscillations in salinity and in the general filling of the gulf. The ancient tributaries have been identified and mapped for many miles over the deserts east and west of the Nile.

It is now becoming evident, however, that the Nile Valley in the Sudan (Berber and Dongola provinces) was not elevated and depressed in this way, or at least that the river was not there induced to aggrade or deepen its valley. The Lower Tertiary level of the country adjacent to the Nile and the lower part of the Atbara differs but little from that of Pleistocene gravels and Recent alluvium.[4] A lacustrine fauna has been identified,[5] complicated by one fossil of marine affinities, according to its present identification.[6]

After the filling of the Pliocene gulf, elevation of the land (or fall of sea level) led to recession of marine flooding, and a series of river terraces was cut at 300, 200, and 150 feet above present alluvium (Figs. 2 and 6). These benches have been traced through Egypt to the Second Cataract, and there is good reason to suppose that they were graded throughout the river valley to this point, regrading taking place at each level. None of these stages have been recognized south of the Second Cataract; the river there seems to have remained undisturbed while vertical movements were taking place in the Medi-

[4] K. S. Sandford: Lower Tertiary Rocks in the Province of Berber, Anglo-Egyptian Sudan, *Geol. Mag.*, Vol. 70, 1933, pp. 301–304.

[5] L. R. Cox: On Fossiliferous Siliceous Boulders from the Anglo-Egyptian Sudan, *Abstracts of Proc. Geol. Soc. of London, 1932–1933*, 1932, pp. 17–18.

[6] *Idem*: A Lower Tertiary Siliceous Rock from the Anglo-Egyptian Sudan, *Bull. l'Inst. d'Égypte*, Vol. 15, 1932–1933, pp. 315–348; reference on pp. 343–345.

EXPLANATION OF FIGURES 2, 3, AND 4. FIGURE 2 shows (*a*) The Nile Valley excavated to its general Middle Paleolithic level, with remains of Lower Paleolithic terraces surviving on the banks, the whole cut in Pliocene deposits filling the more ancient valley.

(*b*) Late-Mousterian and later Paleolithic phase with silts piled upon the general Mousterian level and overlapping the older Paleolithic terraces in Upper Egypt. In Lower Egypt such deposition as took place during this phase was preceded by a marked deepening of the river bed below the general Mousterian level.

(*c*) Last Paleolithic phase, showing excavation of river channel throughout its course, at least from the Second Cataract northward. Existing data suggest that the deepening was much greater in the north than it was farther south. The great deepening of the channel in Middle and Lower Egypt may have been accomplished largely in the stage of (*b*), and if this was so the silts, etc., of that stage are so much the thicker. The sequence given in these purely diagrammatic figures serves to illustrate as clearly as possible the processes involved and their significance from the archeologist's point of view.

(*d*) Final phase, Neolithic, Dynastic, and continuing to the present day, showing some deposition of alluvium in Upper Egypt and Nubia, where it is least; filling of the deep channel farther north, burying of the older silts (Paleolithic), and continued annual increment of alluvium during historical times. (Reproduced from K. S. Sandford: Recent Developments in the Study of Paleolithic Man in Egypt, *Amer. Journ. of Semitic Languages and Literatures*, Vol. 48, 1931–1932, pp. 170–183; reference on pp. 182–183.)

FIGURE 3 shows a section of the Nile Valley in Upper Egypt. (*A-A*) Surface upon which flood-plain gravels of the Nile accumulated in Mousterian time, before aggradation, and river channel of that time; (*A-A'*) lateral valley of the same period; (*B*) valley gravels at end of 10 to 15-foot aggradation and Nile deposits, reëroded, below alluvium; (*B'*) remains of Sebilian silts, resting on the aggraded gravels *B*; (*C*) deep channel proved in bore at Chicago House, Karnak, possibly cut during Sebilian reëxcavation of the Nile Valley; (*D-D*) modern alluvium and river channel. (Reproduced from "Prehistoric Survey of Egypt and Western Asia," Vol. 3, p. 103, Fig. 25.)

FIGURE 4 shows the gradient of Mousterian and Sebilian deposits between the Nile Valley and the Faiyum. Vertical scale greatly exaggerated. (Reproduced from "Prehistoric Survey of Egypt and Western Asia," Vol. 3, p. 93, Fig. 24.)

FIG. 1—Map of the course of the Nile from Khartoum to the Mediterranean. Scale 1 : 10,500,000.
FIGS. 2, 3, and 4—Cross sections of the Nile Valley in Egypt (2 and 3) and from the Nile to Faiyum (4). *For explanation see note at foot of opposite page.*

terranean portion of the valley (Fig. 9). The same observation applies to two other terraces, at 100 feet and 50 feet above modern alluvium. These are of Lower Paleolithic age, Chellean and Acheulean respectively.

As the terrace levels from the Second Cataract to the sea recall

FIG. 5—Mio-Pliocene cliffs of the Nile Valley stripped of Pliocene sediments near Nag' Hammadi, Upper Egypt.

the altitudes of beaches identified in Algeria and elsewhere on the Mediterranean, certain comparisons with Depéret's classification seem to be valid (Table I).[7] They are made without prejudice regarding the question whether the marine terraces are due to elevation of the land or change of level in the Mediterranean.

There is no reason for interpreting these terraces as indicators of climatic change. There is, in fact, no evidence of desiccation along the Nile until Acheulean time, when its approach may be detected in Nubia, i.e. between the First and Second Cataracts (Table III). Emphasis should be placed on these statements as far as the Nile Valley is concerned in view of the present-day enthusiasm for postulating alternating pluvial and arid periods and their supposed association with glacial phases. Terraces alone are not admissible as evidence of such change of climate.

Middle Paleolithic or Mousterian[8] time brought great changes in the river. Aridity began to affect it profoundly by robbing it of its tributaries progressively from south to north.

[7] For references see "Prehistoric Survey," Vol. 3, p. 43.

[8] The term "Levalloisian" is now generally superseding "Mousterian," which is being restricted to a special meaning. This is discussed by the writer in "Prehistoric Survey," Vol. 3, pp. 67 and 110.

From the Atbara confluence (Fig. 9) northward into the cataract region of the Abu Hamed-Dongola bend of the Nile, gravels of well developed terrace form may be seen at intervals to a height of about 25 feet above the river. Probably of Mousterian age, they were succeeded by enormous accumulations of silt, of late-Mousterian age,

TABLE I—NILE VALLEY AND MEDITERRANEAN TERRACES COMPARED

NILE NORTH OF SECOND CATARACT		MEDITERRANEAN (AFTER DEPÉRET)	
TERRACE ABOVE ALLUVIUM	PALEOLITHIC INDUSTRY	HEIGHT ABOVE SEA	STAGE
300 feet = 91 meters	.....	100–90 meters	Sicilian
200 " = 61 "	.....	60–55 "	Milazzian
150 " = 46 "	.....	.....	"?
100 " = 30 "	Chellean	35–30 "	Tyrrhenian
50 " = 15 "	Acheulean	20–18 "	Monastirian
30 " = 9 "	Middle Paleolithic	8 "	Monastirian
10 " = 3 "			

Between the First and Second Cataracts there are traces of a terrace at 75 feet; no human implements have yet been associated with it. In northern Egypt the 30-foot and 10-foot terraces are replaced at least in part by bed erosion followed by aggradation to 25 feet above present alluvium. It is reasonable to suggest that this may be associated with the Mediterranean regression noted by Depéret.

which in relation to present river level rise from south to north from a few feet about Atbara to 40 feet in Dongola Province.[9] North of the cataracts, near Wadi Halfa, silts and fine gravels of the same age mount to 100 feet. Thence northward their level sinks (Fig. 3) until it corresponds with that of modern alluvium near Nag' Hammadi, in Upper Egypt.[10] In this part of the valley, however, an old Mousterian terrace at 30 feet and a stage of more evolved Mousterian culture at 10–15 feet are widely developed. Farther south both are hidden under the lake silt or are not present, but further work in the Atbara region may conclusively associate these stages. It is already clear that the Atbara had a phase of very active flow in Paleolithic time—a point of considerable importance in the study of its development and of climatic changes.

We may conclude that in remote times the Nile received the drainage of the west side of the Red Sea hills at least as far south as the Atbara. It seems probable to me that the Abyssinian or Blue Nile may also be included as an early and natural headwater, but this

[9] Field work not yet published in detail carried out by the writer and his wife in 1932.

[10] K. S. Sandford: The Pliocene and Pleistocene Deposits of Wadi Qena and of the Nile Valley between Luxor and Assiut (Qau), *Quart. Journ. Geol. Soc. of London*, Vol. 85, 1929, pp. 493–548; reference on p. 538.

FIG. 6

FIG. 7

FIG. 8

FIG. 6—Pliocene gravels capping hills on right, with remains of 250 to 300-foot terrace platform at the foot of the cliff; west bank of the Nile between Tuna and Dalga, Middle Egypt.

FIG. 7—The Second Cataract between Abu Sir and Ashkut, looking eastward from the west bank. Note the accumulation of silt around the granite reefs, the high silts in middle background, the cross channels in granite, defined by joints, and greatly restricted main channel in foreground.

FIG. 8—View westward from Qasr Ibrim, between Kurusku and Abu Simbil, showing abandoned Paleolithic course of the Nile, encumbered with Middle Paleolithic silts covered with drifting sand.

remains to be proved. The addition of the White Nile, which drains the lakes plateau of East Africa, seems to have been accidental and may be attributed to movement along the rift faults. The flooding of the main Nile with enormous quantities of silt in Middle Paleolithic time may have been due partly to this event. The addition from the remote south may have thrown into the river north of Khartoum silt from the great lowland traversed by the new supply of water. Change of climate also played a part by reducing the formerly preponderant percentage of locally derived rock waste in Egypt.

TABLE II—CHANGES IN LEVEL OF FLOOD PLAIN

(Heights in feet above present flood-plain level)

	BERBER-DONGOLA	SECOND-FIRST CATARACTS	UPPER EGYPT	MIDDLE EGYPT	LOWER EGYPT
Plio-Pleistocene	Near present level?	300–200–150	300–200–150	300–200–150	320–265: 230–200: 150
Chellean . . .	"?	100	100	100	100
Acheulean . . .	"?	50	50	50	(50)
Middle Paleolithic	25	..	30	(30)	?
Middle Paleolithic	25?	ca. 0?	10	10–15	25
Late and post-Middle Paleolithic . . .	12, 40	100	60, 0	–10, –20	–?
End of Paleolithic	Erosion?	Erosion	Erosion	Erosion	Erosion
Neolithic to present day .	"	"	Accumulation	Accumulation	Accumulation

The data for Lower Egypt proper remain to be published; the figures given above refer to the southern part, i.e. the north end of Middle Egypt, and are taken from the volume on Upper and Middle Egypt recently published ("Prehistoric Survey," Vol. 3). Plio-Pleistocene levels above 320 feet are known in Lower Egypt. If the analogy with the Mediterranean levels is admitted, the terraces at 300, 200, and 150 feet may be included in the Pleistocene. Figures in parentheses denote that the terrace is very fragmentary or is involved with other deposits. The local terrace at 75 feet a little south of the First Cataract is omitted. The levels 10–15 and 25 feet in Middle and Lower Egypt respectively denote aggradation to those levels from below the present flood plain; their lower limit is concealed. The figures –10, –20 likewise show levels now known below present flood plain. The work of P. Bovier-Lapierre should be consulted for the Lower Paleolithic cultures of the Cairo district (Le Paléolithique stratifié des environs du Caire, *L'Anthropologie*, Vol. 35, 1925, pp. 37–46).

The whole problem of silt accumulation in Egypt is ultimately associated with these great changes in the river, of which man was a witness. It has received detailed attention, as far as Paleolithic Egypt is concerned, in the volumes published by the Oriental Institute. The ancient silts that disappear beneath modern alluvium near Nag' Hammadi have now been traced in the deep bed of the Nile and the

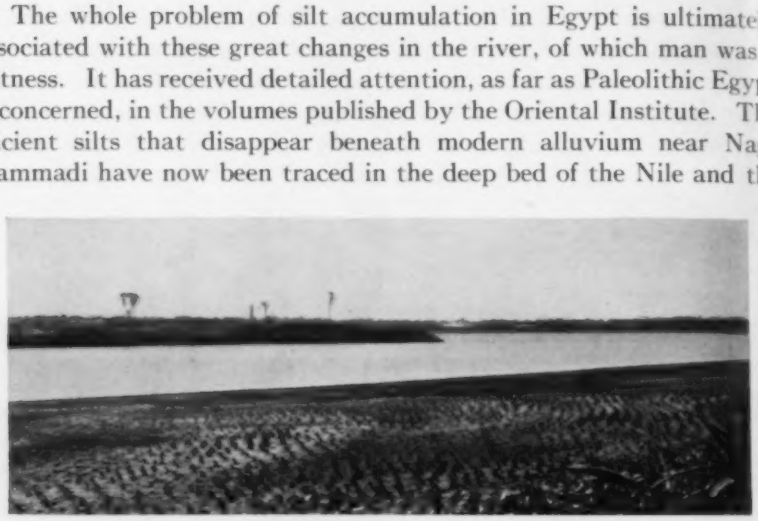

FIG. 9—Junction of the Atbara River, left, and the Nile, right, illustrating the low, broad silt banks without high terraces (compare the tumultuous cataract regions and high terraced valley sides of the north).

downward slope of their upper surface followed as far as Beni Suef. They have been found to correspond with levels of lakes in the Faiyum depression, which the Nile supplied with water. Three separate and distinct sets of levels in the Nile Valley and in the depression, each with its contained human implements, may now be recognized, ranging from Mousterian to a late or Upper Paleolithic age (Fig. 4). Connection between the valley and the depression was then modified by the Nile's cutting its bed yet deeper, and the Faiyum is believed to have drained for a time into the Nile instead of the reverse. Renewed aggradation of the river from the Mediterranean almost to the First Cataract, still in progress, reëstablished the overflow into the Faiyum, which has been kept in control during historical times only by great irrigation works.

Oscillations of river and of land or sea (or both) have thus been identified, measured, and dated—small in the Sudan and more marked progressively toward the Mediterranean. Climatic changes have been similarly recorded, and their progress determined. It has been discovered also that certain industries have survived longer in the Nile Valley than elsewhere, and that other industries scarcely reached the valley. This applies especially to late or Upper Paleolithic cultures and to those established on the west side of the growing deserts. Their absence or scarcity in the valley and their distribution are matters of special interest. There are even certain differences of distribution between the industries of the valley and those of oases little more than a hundred miles away from it. Nevertheless, if we make reasonable

allowances for such factors as these and remember that the chances of rain on the western plains are less (until the continental divide is approached) than they are on the long eastern watershed near the Nile in Egypt, we find that, despite local variations, there is a preponderant amount in common in the development of the Quaternary history of the different parts of the region.

Tables II and III summarize the information discussed above.

It may be asserted that these tables deal only with the deposits formed while the Nile was at high levels; that, since the sea level was lowered during the glacial epochs, the Nile conformed; that the climates indicated in the table are those of interglacial times only; and

TABLE III—CHANGES IN CLIMATE ALONG THE NILE

	BERBER-DONGOLA	SECOND-FIRST CATARACTS	UPPER EGYPT	MIDDLE EGYPT	LOWER EGYPT
Plio-Pleistocene	No evidence that the country was a desert				
Chellean . . .	?	No evidence that the country was a desert			
Acheulean . . .	?	Becoming desert	Not desert	Not desert	Not desert
Middle Paleolithic	Not desert?	Desert?	Not desert	Not desert	Not desert
Middle Paleolithic	Not desert?	Desert	Becoming desert	Not desert	Not desert
Late and post-Middle Paleolithic . . .	Desert	Desert	Becoming desert	Not desert	Not desert
End of Paleolithic	Desert	Desert	Desert	Becoming desert	(Semidesert)
Neolithic to present day .	Desert	Desert	Desert	Desert	(Semidesert)

It must be remembered that each of the divisions given above covers two degrees of latitude or more, with wide differences of altitude and nature of the country rock in the vicinity of the river. The statements made are therefore an attempt to strike a mean for each division for a given period; i.e. each division was undergoing progressive change, on the whole from south to north, once aridity began, until it became absolute desert. At the present day the southern part of the Berber-Dongola division receives rains and includes scrub and grassland; the northern part is rainless and absolute desert. The last two entries under Lower Egypt show that this division received rain from Mediterranean storms, as at the present day. These storms sometimes stray much farther south, into Middle and Upper Egypt, and in the past probably did so oftener. The table is therefore to be considered as an approximation, the detail of which will be found under "Climate" in the Oriental Institute publications.

that the glacial epochs may have been accompanied by pluvial interludes in Egypt and the Sudan, the fluviatile deposits of which are now drowned.

I do not think that such an association of pluvial and glacial is proved even in general terms,[11] and the demonstration of the progressively northward march of aridity is not affected. If the low-level (glacial-time?) deposits of the Nile are for the most part obscured, the supposed rainy periods should have left their mark in the tributaries and adjoining plains and plateaus. But the drainage of the country, once it dried up, remained inoperative, and, to the best of my knowledge, there is no sound reason for supposing that there were in the south any alternations of functional and nonfunctional drainage of the order that we might grace with the titles "pluvial," "interpluvial," or "intrapluvial." In the north the country became desert, in my opinion, only at the close of the last glacial epoch.

The recognition of deposits of known age below the modern alluvium sets for the first time a lower age limit to the strata that doubtless contain the remains of ancient Egyptian civilizations. The study of the river's former meanders and changes of course also determines those regions of alluvium that may be assumed to be barren of such remains and those that would repay exploration if the technical difficulties of examining waterlogged alluvium, sand, and silt can be overcome.

[11] K. S. Sandford: Pluvial and Glacial Climates, *Antiquity*, Vol. 9, 1935. pp. 343–347.

THE IMPACT OF WESTERN CIVILIZATION ON NEGRO AFRICA*

Walter Fitzgerald
Victoria University of Manchester

A MAP showing the distribution of native-population density in Africa today would differ in important details from one for 1870, in which year mining enterprise on a considerable scale may be said to have begun in the Dark Continent. The richest fields of metals so far discovered happen to coincide with areas of low population density, and in order to make possible the uninterrupted exploitation of the mines it has been necessary for the industrialists to promote native immigration from the densely populated areas. The Witwatersrand gold field and the copper belt of Katanga–Northern Rhodesia are the principal magnets of native labor, and to them the Bantu have traveled long distances, most of them more than 400 miles. Such migration inevitably weakens the fabric of tribal life; and, unfortunately, there has been little provision for the social and economic welfare of the many hundreds of thousands of industrialized or urbanized natives who have abandoned the traditional life with its sanctions

*A review of developments discussed in recent publications. The materials on which this paper is based are only an indication of the voluminous literature on African native society that has appeared during the last few years. Not all the phases of this literature are of importance to the geographer, and in this paper the task has been to emphasize only those in which the geographical factor is especially conspicuous. The chief works consulted are:

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T. W. Wallbank: The Principles and Organization of British Native Rule in Tropical Africa, *Pacific Hist. Rev.*, Vol. 3, 1934, pp. 142–155.

and privileges. Disintegration of tribal society has gone farthest where economic necessity—including the payment of an annual poll tax—has forced male natives to leave their kraals to seek work from the white master; it is least serious where the government, having declined to adopt or being prevented from adopting a policy of European settlement and of economic development along Western lines, aims rather at increasing the productiveness of native lands. In this discussion it is convenient to classify African territories on the basis of governmental attitude toward landholding and development. In each of the categories are lands where momentous events have occurred during the past few years—events affecting the very existence of African societies. To some of these events we now turn our attention.

The Union of South Africa and Southern Rhodesia

In the subtropical south the Europeans—Dutch and British—have claimed the ability to settle permanently, though this does not mean their engaging in the hard manual labor of field and mine. Acclimatization of Europeans here remains doubtful as long as there is complete dependence on the muscular strength of the natives. Another argument against successful colonization by the white man might be based on the emergence and widespread growth of a degenerate poor-white class. The Union of South Africa and Southern Rhodesia are "mixed states" whose futures will record the coexistence of two principal societies, black and white, the white numerically a minority but socially, economically, and politically dominant, having much the greater part of the fruitful land in its possession.

The student of native policy in South Africa attaches special significance to the Ciskeian and Transkeian territories of the Eastern Cape Province, which are virtually one vast native reserve. Here, during the final decade of the nineteenth century, European conceptions of land tenure, with their emphasis on individual possession, were introduced and afterwards widely extended. Accompanying this revolutionary innovation was the introduction of British principles of government, including the franchise and parliamentary institutions, both of which are as alien as individual landholding to the communally minded native accustomed to unquestioned obedience to his chief and to tribal tradition. This "Transkeian system," as it is known, is a wide departure from the theory and practice of "indirect rule," which, although abstaining from any abrupt fundamental alteration in native institutions, would help prepare the indigenous civilization to meet the inevitable impact of Western ideas. Nevertheless, the Transkeian system stands for a native policy more enlightened and more generous than that adopted in any other part of the Union, and it is now officially recommended for extension throughout the reserves of the Transvaal, Natal, and the Orange Free State.

The Cape Province—its eastern part more especially—has inherited from early colonial days a more liberal attitude toward the political status of the Bantu than is found in the other provinces, particularly those where Dutch influence is strongest. Educational and property tests were, until a year or so ago, the sole qualifications for the franchise for white and black alike, whereas outside the Cape racial discrimination has always been the rule. In recent legislative enactments racial discrimination has been extended by federal authority to the Cape Province also, and it is now proposed that the Union natives shall be represented in Parliament by four European senators, whose participation, however, will be restricted to native affairs.[1] This "political segregation" of the Bantu is in line with the "color bar" legislation introduced since 1927 and intended to deprive the native of the means of ever reaching economic equality with the European.

Standards of husbandry in the Transkeian Territories and, indeed, throughout the reserves of the Union remain low, and the Native Economic Commission, which toured the country between 1930 and 1932, found abundant evidence of rapid soil erosion, due partly to overgrazing, an almost universal practice among the cattle-owning Bantu. There can be no improvement in native farming methods until the white community resolves to spend money and effort generously on the agricultural education of the native. Although the Commission recommends that the native reserves should be assisted to reach a self-supporting basis, the intention is not to check but only to regulate the migration of natives to the European areas that depend on the Bantu laborer for unskilled and the lower grades of skilled work. As it is, the powerful gold-field industrialists, forced to rely increasingly on Union sources of labor (as noted below), are unlikely to grant their adherence to a policy that, by making the reserves more self-supporting, tends to impede the drift of wage-seeking natives to the mines. The formerly much-discussed policy of segregation of the races is finally dead and buried—inevitably since European society must depend on black labor.

In December, 1930, the Eastern Cape Province provided the Transvaal gold field with 80,000 native miners. The other territories making large contributions were the southern part of the Portuguese colony of Mozambique (74,000), Basutoland (27,500), and the Transvaal (12,500). To the total of Mozambique natives should be added nearly 15,000 who, in 1930, were at work in the Transvaal collieries. Since 1928, by the terms of the Mozambique Convention, the number of natives recruited for the Transvaal from Portuguese territory has been steadily reduced, and it was arranged that during 1935 and thereafter the maximum number to be employed at one time should not exceed

[1] See "Native Policy in South Africa," by an Afrikander Correspondent, *The Round Table*, No. 100, 1935, pp. 722–734, especially pp. 726–727.—EDIT. NOTE.

80,000. Immigration into the Union includes each year some hundreds of Nyasaland natives, and, although it is well-nigh impossible to close the frontiers, the entrance of negroes from north of latitude 22° S. is expressly prohibited, one reason being the very high mortality from pneumonia in the mining labor drawn from the tropics.

Geographically the most interesting development in the affairs of Southern Rhodesia is the introduction of "possessory segregation," by which is meant the separation of the black and the white communities as far as landholding is concerned. The intention is to prevent the growth of a chaotic condition similar to that in the Union, where about half of the natives are detribalized, landless, and, indeed, without any properly recognized social status. Southern Rhodesia does not intend to be generous to the extent of allocating to the natives a reasonable share of the extensive high veld—mostly profitable land, practically all of which is to remain a "European reserve." But, in addition to guaranteeing to the natives the possession of their existing reserves, the government has set apart additional neighboring lands for native purchase, and in these lands individual tenure will be encouraged. Especially noteworthy and constructive is the decision to establish village settlements for the Bantu in the vicinity of the European townships.[2]

The South African Native Territories or Protectorates

The Bechuanaland Protectorate, Basutoland, and Swaziland differ greatly from one another in area, potential resources, and density of population, though their standards of civilization are similar in the main, and they have for the most part remained outside the range of European settlement and exploitation. In the aggregate their Bantu inhabitants number about one million, of whom about half are in Basutoland (of somewhat larger area than the state of Maryland), whereas the European total is only some ten thousand, including many temporary residents. Although these territories are still outside the federal framework of the Union of South Africa, their transfer was foreshadowed in the Act that, a quarter of a century ago, brought the Union into existence; and since General Hertzog's first election as prime minister in 1924 the transfer has been requested on more than one occasion. It is extremely doubtful whether the British government, now directly responsible for the administration of the protectorates, has a legal right to permit the transfer except with the consent of the natives, since the territories were not conquered but were acquired either by treaty or at the request of the paramount chiefs concerned. It may be added that opposition of the tribesmen to the proposal would almost certainly be unanimous.

[2] See Mrs. Tawse Jollie: Native Administration in Southern Rhodesia, *Journ. Royal Soc. of Arts*, Vol. 83, 1935, pp. 973–985.—Edit. Note.

From the economic viewpoint the attachment of all three protectorates to the Union has been secured by a customs union and the extension to them of the Union's tariff policy, which, whatever its advantages to the Union, is certainly not framed to meet the economic needs of backward native areas. Impoverished though they are, the tribesmen prefer their present condition and the security of their lands to the tutelage of the Union, whose record in native affairs is not of a kind to arouse Bantu enthusiasm.

Geographical situation is the circumstance that determines the economic association of the Union and the protectorates. The Basutos and the Bechuana desire to sell cattle, the Swazis need to export tobacco, and for them all the Union, especially the Rand, provides the market. Furthermore, the institution of the poll tax forces many protectorate natives to seek wages, and the Rand offers the largest market for labor also. The gold mines employ annually between 40,000 and 50,000 protectorate natives, and the Chamber of Mines, ever watchful to ensure an abundant and cheap labor supply, regards the transfer of the territories as a necessary means to that end.

Bechuanaland is mostly semidesert—a large portion of the Kalahari is included—and has been described as "marginal ranching country." At present it is virtually bankrupt and without even the funds to establish an administrative capital, so that Mafeking in Union territory serves as headquarters of the protectorate government. The impoverishment of the tribes is shown by the poor quality of their cattle, practically their only resource. The Union—the potential cattle market—demands a better animal than the meager grazing and the primitive Bechuana husbandry have been able to produce.

The tribes are in eight distinct groups. The population is not well distributed in relation to the scattered water resources, and congestion in certain districts suggests the need for a readjustment, which should be one of the immediate undertakings of the government. Outside the reserves are the unalienated crown lands and the "ceded strip" alienated to Europeans and traversed by the transcontinental railroad, which follows the east border of the protectorate between Mafeking and Bulawayo. The European lands include the Tuli, Gaberones, and Lobatsi "blocks," where the rainfall is more abundant than the average for Bechuanaland as a whole and pastures are correspondingly superior. From these parts comes a strong demand for the transfer of the protectorate to the Union, a demand that is related to the ties of kinship and economic interest that attach the settlers to the white community of the Union. In the northeast, on the Rhodesian frontier, is the Tati "block," whose European settlers prefer transfer to Southern Rhodesia.

Although more prosperous than Bechuanaland, Basutoland is still barely self-supporting; yet the revenues of its people are increased by

wages earned by about half of the male adults who every year seek work in the Transvaal. Soil erosion is proceeding apace, and naturally fertile lands are passing into desolation—a condition of things for which the British government must take a full share of responsibility, inasmuch as it has failed adequately to foster native agriculture and stock raising. Lack of modern means of communication, including motor roads and railways, is one of the most telling factors in the general economic stagnation.

Swaziland not only is a well endowed pastoral country but is also known to possess large resources of gold, tin, and coal. Although it is much smaller than Basutoland, most of it has been alienated to European concessionaires, so that the paramount chief has found the utmost difficulty in maintaining the integrity of his tribes and his authority of leadership. More highly taxed than any other tribe of natives in South Africa, the Swazis are forced by necessity to migrate periodically into the Union. Yet the country could easily become self-supporting, given improvement in the standards of farming, which are still very low despite the widespread use of the plow.

The Tropical Highlands

We may group together the well watered lands of high altitude (more than 5000 feet above sea level) within tropical latitudes, in which Europeans have settled since the beginning of the twentieth century. Successful acclimatization here, however, is even less likely than in white South Africa. The technical equipment of European husbandry has been introduced, but the European capitalist farmer chooses, or is forced by a hostile climate to depend exclusively for field labor on the prolific Bantu population, from whom the land has been taken.

By reason of larger area, more extensive European settlement, and greater density of native population, the Kenya highlands, in the southwestern part of the colony, provide the outstanding example in the African tropics of a conflict—with land as the prize—between the Bantu, doomed by his lack of organization and scientific equipment to a losing struggle, and the European settler, who demands very extensive acreage for his farming. Interpretations of British colonial policy in regard to the allocation of land have not been consistent since the year 1923, when, for the last time, the Colonial Office seemed to take a stand in the matter of the protection of native interests. In 1935 an official announcement from London left no doubt that henceforth the highlands are to be regarded as a European "reserve," just as in Southern Rhodesia the high veld is so regarded. The Kenya Land Commission of 1933 surveyed the existing native reserves in relation to both the economic needs and the territorial claims of the

natives and made recommendations for the provision of additional native areas, though these in the aggregate are too small to affect materially the extreme disproportion between the average area of land per capita held by Europeans and that held by natives. For Europeans, this is about 600 acres, no part of which is infertile; for natives, 8 acres, of which at least one-quarter is too sterile for cultivation or pasture.

The pressure of population on the land in the Kikuyu reserves is greater than in the Transkeian Territories. As in the South African zone, cultivation remains primitive, despite the use of the plow, and manuring is still unappreciated. The Bantu practice of overgrazing is also widespread. Yet even by Western standards of land utilization, a rural density of 253 persons to a square mile—the figure for the Kikuyu reserves—is high. The Land Commission rather complacently reports that the Nandi reserve of western Kenya could easily support a density of 300 to a square mile. The outstanding recommendation of the report is that individual tenure, already extending, should be encouraged throughout, in order to raise the standards of farming; other ways of assisting native agriculture that would involve an outlay of finance and effort on the part of the European community have not been so prominently recommended.

Perhaps even more difficult than the position of the Kikuyu is that of the Masai, who are exclusively pastoralists. Today the Masai reserve is in the southwestern part of Kenya and amounts to nearly 15,000 square miles, but the Land Commission omits to emphasize enough both the aridity that makes much of this area impossible as grazing country and the indisputable fact that, before 1911, some of the best Masai lands were in the Laikipia region, from which the tribe was expelled in the interests of European settlement.

The Mining Zones of the Tropics

At lower plateau altitudes (about 2000–3500 feet above sea level) in the African tropics there are rich mineral-bearing lands that are being exploited by Western capital and technical skill but in which, owing to the unfavorable climate, there can never be a future for the white man as a permanent settler. The copper belt of Katanga–Northern Rhodesia and the newly prospected gold field of Kavirondo (western Kenya) are the areas especially noteworthy.

Soon to rival in industrial magnitude the gold-bearing reef of the Transvaal is the copper belt that extends across the Belgian Congo (Katanga)–Northern Rhodesia frontier. The proved resources equal, it is estimated, more than one-third of the world's known reserves of copper, and of their vast extent the Belgian Congo seems to possess much the larger share; furthermore, the ore is more accessible there

than in Northern Rhodesia. Output has been mainly from Katanga; in British territory production was not considerable until 1923. Even as recently as 1930 there were 40,000 Northern Rhodesian natives working outside the protectorate[3]—a clear indication of the immaturity of the local industry at that time.

In this region of wooded savana the population is scattered: in the neighborhood of Ndola—the center of the Rhodesian mining zone—the density is only slightly more than 2 to a square mile. On the Rhodesian side the most thickly settled areas, where a surplus available for mining labor is sought, are distant from the copper belt and on the margins of the protectorate, from which there is a tendency to move across into neighboring territory. For example, many natives of East Luangwa migrate to Southern Rhodesia (in 1931 more than 10,000 of them); from districts near the Tanganyika frontier there is movement across to the cotton and sisal plantations of the mandated territory; and in the west, numbers of the Barotseland people are accustomed to seeking work in South-West Africa. It is estimated that nearly half of the able-bodied adult male population of the protectorate are periodically away from the kraals. On the Belgian side, one of the principal sources of labor for the Katanga mines is the far-distant Ruanda-Urundi mandated territory, from which in 1931 the great mining corporation, the Union Minière, recruited 25 per cent of its laborers. In the Katanga Province itself the recruitment of labor has been carried too far, and the effect on native society has become so serious as to lead the government to impose drastic restrictions. The province is divided into sections from each of which is drawn only the number of males it can afford to lose temporarily without dislocation of tribal life. The limits imposed may be realized by reference to a village of 400 people, whose maximum contribution must not exceed 8 male adults.

In this industrial zone Belgium and Great Britain adopt different attitudes toward the social and economic status of the native. Like France, her political and cultural ally, Belgium recognizes no "color bar" in her colonial empire. The South African attitude, characteristic of the Union and to a less degree of Southern Rhodesia also, demands a legal barrier to the political and economic, as well as the social, progress of the Bantu. Northern Rhodesia for the time being holds a midway position. The first British settlers, coming mainly from white South Africa, brought with them the characteristic attitude of that society toward the native; but because of the extreme paucity of European skilled labor in these tropical latitudes it was not possible rigidly to apply racial discrimination in industry. The same may also be said of the other British dependencies of tropical Africa, though in

[3] Although nominally a "protectorate," Northern Rhodesia, like Nyasaland, is virtually a crown colony.

Tanganyika Territory such discrimination is prohibited by the terms of the mandate. Legally there is no "color bar" in Northern Rhodesia, but strong pressure is being brought to bear on the government with a view to its introduction.

In the copper zone the mines have created nucleuses of native settlement that, it is hoped, may be fashioned into properly regulated townships. The "municipal location" of Ndola, for example, consists of 1700 mud-and-wattle huts, built by successive families of mining natives. What is urgently needed is the development in the rural areas of Central and East Africa of nucleuses comparable, say, to European market towns, which would be trading centers for native craftsmen as well as markets for the exchange of products. A recent report suggests that the villages of the paramount or subordinate chiefs might be developed in this way.

Tropical Dependencies with Native Interests Paramount

As in the mining zones, climate in these dependencies provides an unassailable barrier to white settlement. In contrast, however, with the policy in the mining zones, no immediate intention of further expropriation of native lands is entertained. Typical examples are the four British West African colonies and protectorates, the Uganda Protectorate, and a large part of the Belgian Congo. (In the French federations of West and Equatorial Africa a different conception of the natives' destiny prevails.)

In British West Africa and the Uganda Protectorate the paramountcy of native interests has long been recognized as the guiding principle of policy, and the position of the negroid peoples has not materially altered there during the last few years; but in the Belgian Congo, except for the mining zone of Katanga, the principle is of much more recent application and has replaced a former ruthless exploitation. The days of Leopold II are not very distant, and the evil heritage of the concession system that he introduced has died hard. Since 1908, however, when the Belgian government became directly responsible for the welfare and administration of one million square miles and some nine million inhabitants, a new conception has pervaded the relationships of European and Native. In many ways it resembles Lugard's "indirect rule," devised and applied by him in Nigeria. Native policy is now based on the "evolutionary" principle, and both civil law and criminal law are kept closely compatible with local custom. Forced labor, which in its worst phases was an outrage on civilization, is practically abolished except in rare cases of requisition for porterage, and present conditions of labor compare favorably with those of any other territory in tropical Africa.

It is economic development, however, that provides the real test

of a government's policy regarding native welfare. Even if it is agreed that large-scale mining in Katanga and other parts of Africa must remain a European capitalistic enterprise, there is a practical alternative to "plantation" agriculture. Peasant farming for subsistence as well as for export or cash crops has passed through many vicissitudes in Uganda and the Gold Coast but, in the long run, has proved to be an outstanding success both in raising the economic and social status of the native and in providing a considerable export trade, of which the huge cocoa exportation of the Gold Coast is an example. Most Belgian colonial experts believe that the interests of the Congo will best be served by a similar development of peasant agriculture, and already in a variety of ways the government has stimulated its advance. All natives are obliged to grow subsistence crops, and throughout a large part of the Congo where conditions are favorable they are also required to grow cotton as an export crop, the native farmer being guaranteed a minimum selling price when the raw product is brought to the ginnery. Professor Ryckmans is of the opinion that the number of persons engaged in cotton planting is not less than one million, a remarkably high total in view of the fact that cotton was introduced little more than twelve years ago.

The recent period of trade depression has served to emphasize the slender resources possessed by Belgium for the economic development of its vast Central African empire. There are critics who maintain that the network of transport routes that has been built up is too costly to keep up at its present extent and, indeed, should not have been constructed until the prospects of a satisfactory return on outlay were more promising. This argument is countered by the view that, had railway development on a large scale not been undertaken, the effective occupation of the outlying parts of the Congo basin would have been impossible, and surrounding colonial powers would have had an excuse for penetration. Now that the international position in Central Africa appears to be relatively stable, there is no longer the fear of territorial loss; and it is suggested, by Ryckmans among others, that on account of the low density of population and the inaccessibility of the remoter parts of the Congo it is better to abandon for the time being any schemes of transport development in these districts and to localize economic enterprise in the neighborhood of existing arterial lines of river and railroad, near which native settlement should also be encouraged. No wholesale shift of population is contemplated, but some of the tribes have already moved their villages to the vicinity of the main routes.

In its record of medical service the Belgian Congo stands high—if not highest—among African colonies. Sleeping sickness has been fought by six or seven medical missions, and until the recent years of financial stress, when services were curtailed, the disease was retreating

on every front: in the districts of Bas Congo, Kwango, and Kasai it was virtually eliminated. One important result of the improvement in native health has been a rise in the natural increase of population. During the early years of European penetration—from 1880 to 1908—there was wholesale depopulation, in which the excesses of the rubber and ivory hunters played their sinister part; but today the rate of natural increase is high throughout the Congo, and a figure of 20 to a thousand, or four times the figure for Belgium, holds for many districts. In the comparatively low-lying interior of the Congo the problem of maintaining the health of both people and livestock is more difficult than within the same latitudes on the East African plateau (especially those parts in which the European has found residence attractive). Considering their very recently assumed role in the Congo, the great natural obstacles to be overcome, and the slender resources of their nation, the Belgians well deserve their reputation as colonial administrators.

CORN YIELD AND CLIMATE IN THE CORN BELT

John Kerr Rose
University of Chicago

THE correlation of variations in corn yield with fluctuations of climatic factors is more than an academic problem. Many of the human activities prominent in the Corn Belt, rural or urban, are directly or indirectly related to corn. Beginning with the preparation of the seedbed in spring and extending intermittently through the harvesttime of late autumn, the larger part of the Corn Belt farmer's time and activities is applied to corn. Wintertime activities include the feeding of animals with corn. Corn Belt villages exist mainly to serve the corngrower. The cities buy, process, and sell the products of the cornland and serve the corn farmer in many other ways. The average yearly value of the corn crop of the United States is roughly one twenty-fifth the total value of all plant products grown in the world suitable for human or animal food.

In recent years corn has occupied yearly about 100,000,000 acres[1] of land in the United States—roughly five times the total area of Indiana. Of these 100,000,000 acres, more than 60 per cent[2] lie in the ten states of which parts are included in the geographical division known as the Corn Belt. On an average, about 19 per cent[3] of the area of Iowa is planted to corn. In the heart of the Corn Belt, however, as much as 40 to 50 per cent of the area is in corn yearly. Here no other crop so dominates the landscape. Corn is king.

Perhaps no other thing about the corn crop is so interlocked with the weal and woe of the Corn Belt inhabitants as the yearly variation in yield. The corn crop of the United States fluctuates from about one and a half to about three billion bushels.[4] The yield per unit area fluctuates notably from year to year. For the state of Indiana, some years give an average per-acre yield more than twice as large as some other years. Iowa, commonly considered a relatively stable state climatically, in some years has an average per-acre yield 300 per cent greater than in others.

No other factor affecting the yield of corn from year to year in a given area fluctuates as does weather, or the longer phase of weather, climate. Soil fertility is more or less constant, as is the care given the crop. Varieties are changed slowly. Reed[5] has found that in Iowa

[1] *Yearbook of Agric., 1932*, U. S. Dept. of Agriculture, Washington, 1932, p. 608.

[2] W. A. Mattice: Weather and Corn Yields, *Monthly Weather Rev.*, Vol. 59, 1931, pp. 105–112; reference on p. 105.

[3] *Ibid.*, p. 106, Fig. 1.

[4] *Yearbook of Agric., 1932, loc. cit.*

[5] C. D. Reed: Weather and Corn Maturity in Iowa, *Monthly Weather Rev.*, Vol. 55, 1927, pp. 485–488.

the yield has increased slowly over a long period of years, owing, perhaps, in the main to better varieties and improved tillage but possibly also to changes in climate. Insect pests are a variable affecting the crop; insect damage, however, correlates fairly well with drought conditions. Thus climatic factors would seem to be the most potent and hence the most worthy of investigation among those causing fluctuations in the yield of this major crop. The tropical or subtropical origin of corn and the wide variety of climatic conditions even within the Corn Belt suggest that there may well be interesting and peculiar responses to the climate under which corn is now so largely grown.

Earlier Investigations

It is not surprising that so important a problem early received attention from scientists. Wren,[6] writing in 1901, summarized the existing knowledge and theories concerning corn yield as related to climate. The earlier investigations dealt with temperature more than with any other factor and made no use of mathematical correlation.

Since that time a number of studies, mostly utilizing mathematical correlation, have been published on the various phases of the relation between corn yield and climate. Smith[7] in 1904 pointed out with the aid of graphs the correlation of corn yield with rainfall for June, July, and August, especially for July. In 1914[8] by means of simple correlation he studied the relation of yield to temperature and rainfall. He found that July was the most important calendar month and precipitation the most important factor. Wallace[9] in 1920 agreed with Smith that July rain was an important factor but not in all parts of the Corn Belt. He concluded that it was easy to predict corn yield from weather in the south half of the Corn Belt but difficult in the north half. Kincer and Mattice[10] in 1928 found several weather factors, mainly for weekly periods, which gave relatively high correlation coefficients. Mattice[11] in 1931 grouped states according to the climatic factors giving the highest correlation coefficients and thereby arrived at a threefold division of the states of the Corn Belt. In that study, too, early-season and late-season factors were first shown to be of considerable importance. Hodges,[12] in an examination of the effect of rainfall and temperature on corn yields in three type-of-farming areas in Kansas, found considerable variation within that state. In 1932 the present writer[13] showed by means of climographs that in Indiana high temperatures are bad for corn yield and that, other factors being equal, a short season between killing frosts gives a higher corn yield than a long frostless season. Huntington[14] in 1933 used the climograph method to show that climate all through the year, and not merely in the growing season, shows a considerable

[6] H. B. Wren: Climate and Corn, *Monthly Weather Rev.*, Vol. 29, 1901, pp. 8–14.

[7] J. W. Smith: Relation of Precipitation to Yield of Corn, *Yearbook U. S. Dept. of Agric. for 1903*, Washington, 1904, pp. 215–224.

[8] *Idem:* The Effect of Weather upon the Yield of Corn, *Monthly Weather Rev.*, Vol. 42, 1914, pp. 78–93.

[9] H. A. Wallace: Mathematical Inquiry into the Effect of Weather on Corn Yield in the Eight Corn Belt States, *Monthly Weather Rev.*, Vol. 48, 1920, pp. 439–446.

[10] J. B. Kincer and W. A. Mattice: Statistical Correlations of Weather Influence on Crop Yields, *Monthly Weather Rev.*, Vol. 56, 1928, pp. 53–57.

[11] *Op. cit.*

[12] J. A. Hodges: The Effect of Rainfall and Temperature on Corn Yields in Kansas, *Journ. of Farm Economics*, Vol. 13, 1931, pp. 305–318.

[13] J. K. Rose: Climate and Corn Yield in Indiana, 1887–1930, *Proc. Indiana Acad. of Sci.*, Vol. 41, 1931, Indianapolis, 1932, pp. 317–321.

[14] Ellsworth Huntington, F. E. Williams, and Samuel Van Valkenburg: Economic and Social Geography, New York and London, 1933, Chapter 4.

measure of correlation with corn yields. A still later study by Robb[15] finds fairly high simple correlation coefficients between yield and rainfall for July and August in northeastern Kansas.

Purposes and Technique of This Study

In the present study of the problem the whole Corn Belt has been dealt with on the basis of numerous selected county units. The correlation coefficients calculated for these samples provide a basis for the determination of transitions from areas in which yield is influenced by one factor or set of factors to those in which it is influenced by others. As a result, more detailed and probably more reliable information regarding the correlation of corn yield with climatic factors within, and just beyond the margins of, the Corn Belt is available. Such information, besides being an addition to geographical knowledge, may contribute toward better crop-yield forecasting by government and private agencies. It is not too much, perhaps, to expect that, if the present trends toward planned agricultural economy continue, some information so gained may be found useful in modifying or changing present agricultural practices.

A second purpose of this study is to illustrate the possibilities of what may well be called "statistical method in geography." Field methods serve mostly for the collection of data. The problem of analyzing these data is complicated by the fact that the geographer commonly works with many variables, independent and dependent. Hence the methods of correlation analysis[16] would seem especially promising tools for geographical investigation.

Several of the writers mentioned above made use of statistical correlation. It is significant, however, that these investigators used state averages for data if they wished to cover a large area or else confined their work to one or two small areas. Such areal units were not suitable for the present investigation, in which it was especially desired to discover such variation as exists from area to area. Fifty-five counties, the smallest units for which yield data were available, were studied. Such a number of counties, well distributed over the Corn Belt and just beyond its margins, covered the area fairly closely and also permitted closer spacing in a few areas for which greater detail was desired. These sample counties were not chosen at random. They were selected with a view to covering the Corn Belt as well as possible, and each county was supposed to have fairly uniform soils, topography, etc. Partly for this reason, small counties were preferred to larger ones. In each county there was at least one weather station, fairly representative of conditions in the county. In the selection of the samples, office work, conferences, reconnaissance, and traverses in the field were supplemented by firsthand knowledge of parts of the Corn Belt.

Inasmuch as it was planned to consider the areal distribution pattern of the coefficients for the Corn Belt as a whole, it seemed best to have data for the several

[15] A. D. Robb: The Critical Period of Corn in Northeastern Kansas, *Monthly Weather Rev.*, Vol. 62, 1934, pp. 286–289.

[16] For a simple exposition see Mordecai Ezekiel: Methods of Correlation Analysis, New York, 1930. Chapters 3, 4, and 5 are especially recommended to those not familiar with simple concepts of correlation.

states as comparable in period as practicable. In connection with this question, correlations of yield with several climatic factors were run for a number of Iowa counties for three widely different periods. The results obtained showed that, although the coefficients varied somewhat in value with change in the length of period, they did not change greatly in significance: those of little significance remained so, and the significant ones remained significant. Even so, it was necessary to use a shorter period of years in some states, notably Ohio and Minnesota, than was desired.

TABLE I—LENGTH OF LONGEST PERIOD STUDIED

STATE	PERIOD*	STATE	PERIOD*	STATE	PERIOD*
Illinois	22	Michigan	19	Ohio	9
Indiana	22	Minnesota	12	South Dakota	16
Iowa	24	Missouri	19	Wisconsin	16
Kansas	24	Nebraska	24		

*In years. All periods end with 1932.

In all, more than 2000 simple correlation coefficients were calculated and then mapped and the isopleths drawn.[17] In numerous cases the relationship was linear; hence linear correlation was employed throughout. Slow upward trends in the yield data of many of the counties were not eliminated, partly because they were slight and partly because such trends are supposedly due, to some extent, to the effects of complicated and incomplete climatic cycles.

Multiple correlations involving in most cases seven independent climatic factors besides the dependent factor of yield were calculated for 29 counties. The resulting multiple correlation coefficients are shown on Figure 12. The climatic factors included in the multiple correlations commonly varied from one part of the Corn Belt to another. Factors to be included were selected on the basis of the simple correlation coefficients obtained. The results obtained in the multiple problems were calculated for neighboring samples and so as to cover the months May through August.

Two tests of the significance of the coefficients are the numerical value of the coefficient and the question whether or not the coefficient fits into the areal distribution pattern. In this study, if the coefficient is as high as ±.40 or higher, it is of considerable significance, statistically speaking, being three or more times the probable error. Even so, if it stands isolated in the areal distribution pattern of coefficients, its significance is to be seriously questioned.

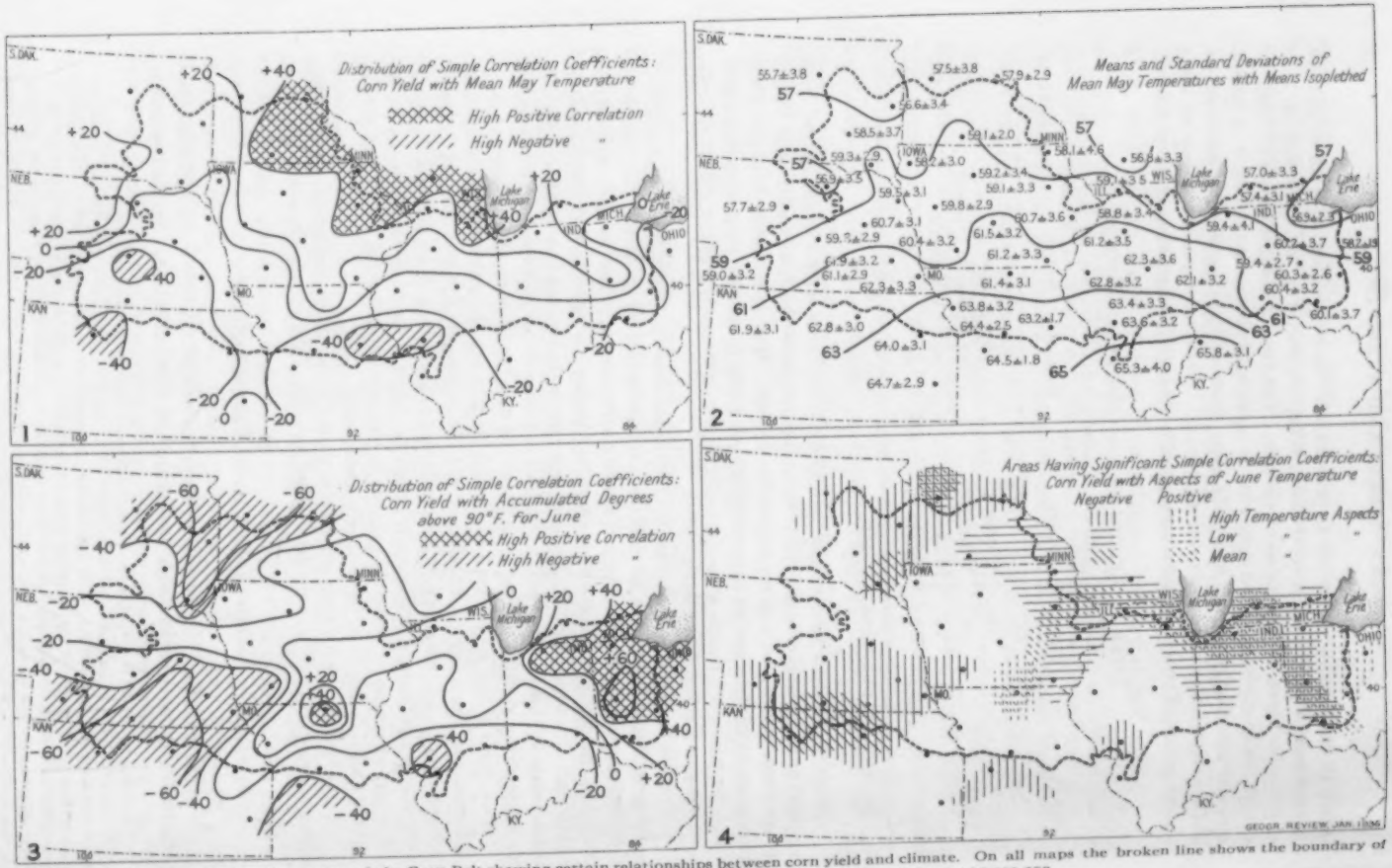
In this investigation simple correlation coefficients of corn yields with 35 climatic factors or aspects of factors were determined for each of the 55 counties studied.[18]

CORN YIELD AND TEMPERATURE

An important part of this study has been devoted to correlating variations in corn yield with variations in temperature. Some twenty-

[17] It is suggested that isopleths applied to correlation coefficients be called *isocorrelates*.

[18] The 35 climatic factors and aspects of factors were: for May, June, July, and August: precipitation, mean temperature; for June, July, and August: accumulated degrees above 90° F., days having temperatures 90° F. or above, accumulated degrees below 60° F., nights having temperatures 60° F. or lower, clear days, partly cloudy days, cloudy days, rainy days (0.1 inch or more); length of the growing season measured in days between killing frosts; number of days before June 1 that the last killing frost in spring occurred; July rainfall weighted so as to eliminate the effect of local thundershowers upon a single station in any one year. Other factors and those mentioned for other months were also investigated to some extent.



FIGS. 1–4—Four of a series of 12 maps of the Corn Belt showing certain relationships between corn yield and climate. On all maps the broken line shows the boundary of the Corn Belt, and the dots represent the centers of the 55 counties studied (for list see caption to Figs. 5–8). Scale: 1 : 19,000,000.

one maps were drawn up to show the distribution of correlation coefficients between corn yield and various aspects of temperature during the spring and summer months. In general it was found that over large parts of the Corn Belt temperatures correlate more significantly with corn yield than has previously been believed.

Figures 1 and 2 show a sample pair of maps for mean monthly temperature. The areal distribution pattern of coefficients between corn yield and mean May temperature shows the Corn Belt practically halved by the line of zero correlation. It seems from this that variations in mean May temperature have little effect on corn yields throughout the middle zone of the Corn Belt. It may be said that to the north, roughly, the higher the mean May temperature in any year, the better the corn crop; whereas to the south poorer-than-average yields occur after May temperatures above average. It is seen, however, that in these regions only a few of the coefficients are high enough to be called significant. Thus in only a few relatively small areas would a knowledge of the mean May temperature be of much help as an aid in predicting the yield of corn.

Wallace, using state averages, found very low coefficients between corn yield and mean May temperature. Figure 1 helps to explain why that might be the case: such states as Illinois and Iowa are partly negative and partly positive in regard to this factor. Thus positive and negative areas would tend to cancel each other when included in state averages.

The areal distribution of the coefficients (Fig. 1) corresponds fairly well with the distribution pattern of mean May temperature (Fig. 2). Areas in which higher-than-average mean May temperatures are followed by lower-than-average corn yields have May temperatures of above 61° F.; areas of significant positive correlation have temperatures of 59° F. or lower. Comparison of the pattern of correlation coefficients with other supposedly related distributions sometimes gives positive and sometimes negative results. There seems to be a correspondence between the areal distribution pattern of coefficients and the date of corn planting. For areas in which corn is, on the average, planted before May 1 the correlation coefficients are negative; i.e., the warmer the month of May in such areas, the poorer the yield of corn. The yield in areas in which planting commonly is done after May 1 correlates positively with mean May temperature. There seems to be little correspondence between the distribution pattern of coefficients and such factors as soil and altitude.

One temperature factor that yielded surprisingly widespread significant coefficients is accumulated degrees above 90° F. For all three summer months this factor gave significant results. Figure 3 shows the large areas of significant correlation coefficients between corn yield and accumulated degrees above 90° F. for June. Some of

FIGS. 1–4.—Four of a series of 12 maps of the Corn Belt showing certain relationships between corn yield and climate. On all maps the broken line shows the boundary of the Corn Belt, and the dots represent the centers of the 55 counties studied (for list see caption to Figs. 5–8). Scale: 1 : 19,000,000.

the coefficients are more than seven times the standard error. It is notable that in the southwestern and northwestern parts of the Corn Belt high temperatures in June are bad for corn, whereas in the northeast much warm weather in June seems to be followed by good yields. However, in the area of positive significance there are usually less than ten accumulated degrees above 90° F. Areas having more than 30 accumulated degrees above 90° F. show for the most part relatively high negative coefficients. For this factor correspondence with soil, altitude, yield pattern, and date of planting seems to be lacking.

From an examination of Figure 4 it is plain that June temperature, in one or more of the aspects investigated, has correlated significantly with corn yield in certain parts of the Corn Belt, notably the northeastern, northwestern, and southwestern. On the other hand, it is evident that no coefficient as high as ±.40 has been found for large parts of the region.

June temperatures are significant,[19] highly significant, or even critical in the northeastern part of the Corn Belt. The coefficients are mostly lower than ±.60, but there is no disagreement among aspects; that is to say, high-temperature factors (accumulated degrees above 90° F. and the number of days 90° F. or higher) and mean temperature give positive coefficients, and low-temperature factors (accumulated degrees below 60° F. and the number of nights 60° F. or lower) give negative coefficients. Presumably the corn crop of the relatively humid northeastern part of the Corn Belt commonly needs more heat than it receives during early stages of its growth.

June temperatures are also significant or highly significant in the northwestern and southwestern parts of the Corn Belt. In June, corn is nearing the reproductive stage in the southwest but is considerably less advanced in the northwest. Nevertheless, June heat in both of these subhumid regions of blackerth or chestnuterth soils is too great to favor corn yields. The area of low correlation separating the two regions seems to differ from them in natural factors only in that much of it has deep loess soil.

From the summary map of the correlations of corn yield with aspects of July temperature (Fig. 5) it is seen that the correlations are not to be considered as critical in any part of the Corn Belt. Nevertheless, variations in July temperatures do accompany variations in corn yields in a highly significant manner on the northwest and southwest margins of the Corn Belt and in a significant manner along the whole of the south and east margins. Thus it would seem that July temperatures are somewhat too high for corn along the humid part of

[19] If, of the aspects (high, low, etc.) of a certain factor (June temperature, etc.) investigated for any particular sample, a maximum or near-maximum number gives coefficients above ±.40, that factor is said to be *critical*. If only one of the aspects investigated gives ±.40 or higher, the factor is said to be *significant*. A condition approximately intermediate between significant and critical is spoken of as *highly significant*.

the south margin and decidedly too high on the southwest and northwest margins, where moisture is not plentiful. As for low temperatures, except in an eastern area, July temperatures can scarcely be said to fall so low as to affect adversely the yield of corn.

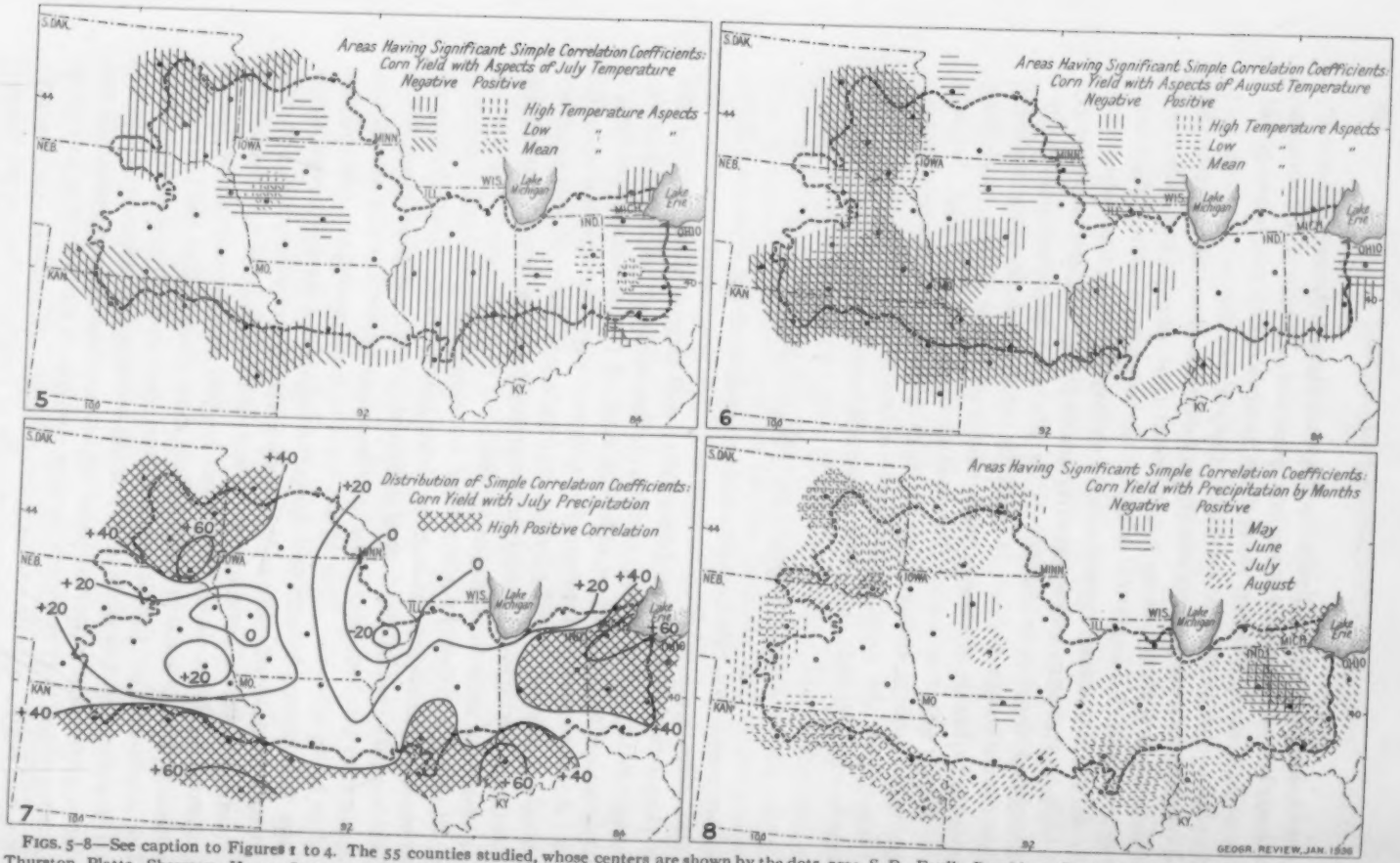
The summary map of correlations of corn yield with three aspects of August temperature (Fig. 6) indicates that August temperatures are to be considered as critical in much of the western part of the Corn Belt. There is no disagreement among the aspects investigated—mean and high temperatures give negative coefficients, and any increase in accumulated degrees below 60° F. is likely to be accompanied by higher-than-average yields. It is worth noting that this western area is one of blackerth or chestnuterth soils and rather scanty precipitation. Along the whole south margin of the Corn Belt high August temperatures seem unfavorable to corn yield. The north margin, particularly in the more humid eastern two-thirds of the Corn Belt, seems to suffer slightly from lack of enough heat during August.

Corn Yield and Precipitation

Two aspects of precipitation have been correlated with corn yield in this investigation. Total amounts of precipitation by months for the four months of May, June, July, and August have been considered—with enlightening results. The number of days having precipitation of .01 inch or more for each of the months June, July, and August was investigated—without significant results. In general, this study hardly bears out the conclusions of those earlier investigators who found variations in precipitation to be an exceedingly important factor influencing corn yield.

Of the four months for which variations in precipitation were correlated with variations in corn yield, July gave the most significant results. July rainfall correlated positively with corn yield in 49 of the 55 counties studied (see Fig. 7). The negative coefficients are all too low to be significant. This would seem to indicate that in most of the Corn Belt more-than-normal July rainfall has a beneficial effect on the corn crop, though few of the coefficients are extremely high.

As is shown in Figure 8, variation in precipitation for any of the four months, May, June, July, and August, significantly accompanies variation in corn yield in only slightly more than half of the Corn Belt. The correlation is almost wholly positive; i.e. with the exception of early-season precipitation in two small areas, above-average precipitation is significantly accompanied by an increase in corn yield. In the southwest and northwest and in an eastern area variations in precipitation are highly significant or even critical. In general, early-season precipitation is a fairly good indicator of corn yield on the northwest, west, and southwest margins of the Corn Belt. Midseason



FIGS. 5–8—See caption to Figures 1 to 4. The 55 counties studied, whose centers are shown by the dots, are: *S. D.*, Faulk, Brookings, Davison, Yankton; *Neb.*, Holt, Blaine, Thurston, Platte, Sherman, Hayes, Lancaster, Franklin, Nemaha; *Kan.*, Graham, Cloud, Shawnee, Allen; *Minn.*, Chippewa, Hennepin, Martin; *Iowa*, Sioux, Winneshiek, Humboldt, Buchanan, Crawford, Polk, Cedar, Adams, Van Buren; *Mo.*, Putnam, Buchanan, Saline, Audrain, Johnson; *Wis.*, Dane; *Ill.*, Stephenson, Kane, Bureau, McDonough, McLean, Macoupin, Coles, St. Clair; *Mich.*, Kalamazoo, Washtenaw; *Ind.*, St. Joseph, Huntington, Tippecanoe, Rush, Knox; *Ohio*, Fulton, Ashland, Shelby, Franklin, Clinton.

precipitation, on the other hand, particularly weighted July rainfall, seems significant in about half of the Corn Belt, but more so in the eastern, northwestern, and southwestern parts.

The data here summarized indicate that the role of rainfall variations in affecting the yield of corn is by no means simple or overwhelmingly important. Only locally is precipitation a very significant predictive factor.

Corn Yield Correlated with Miscellaneous Factors

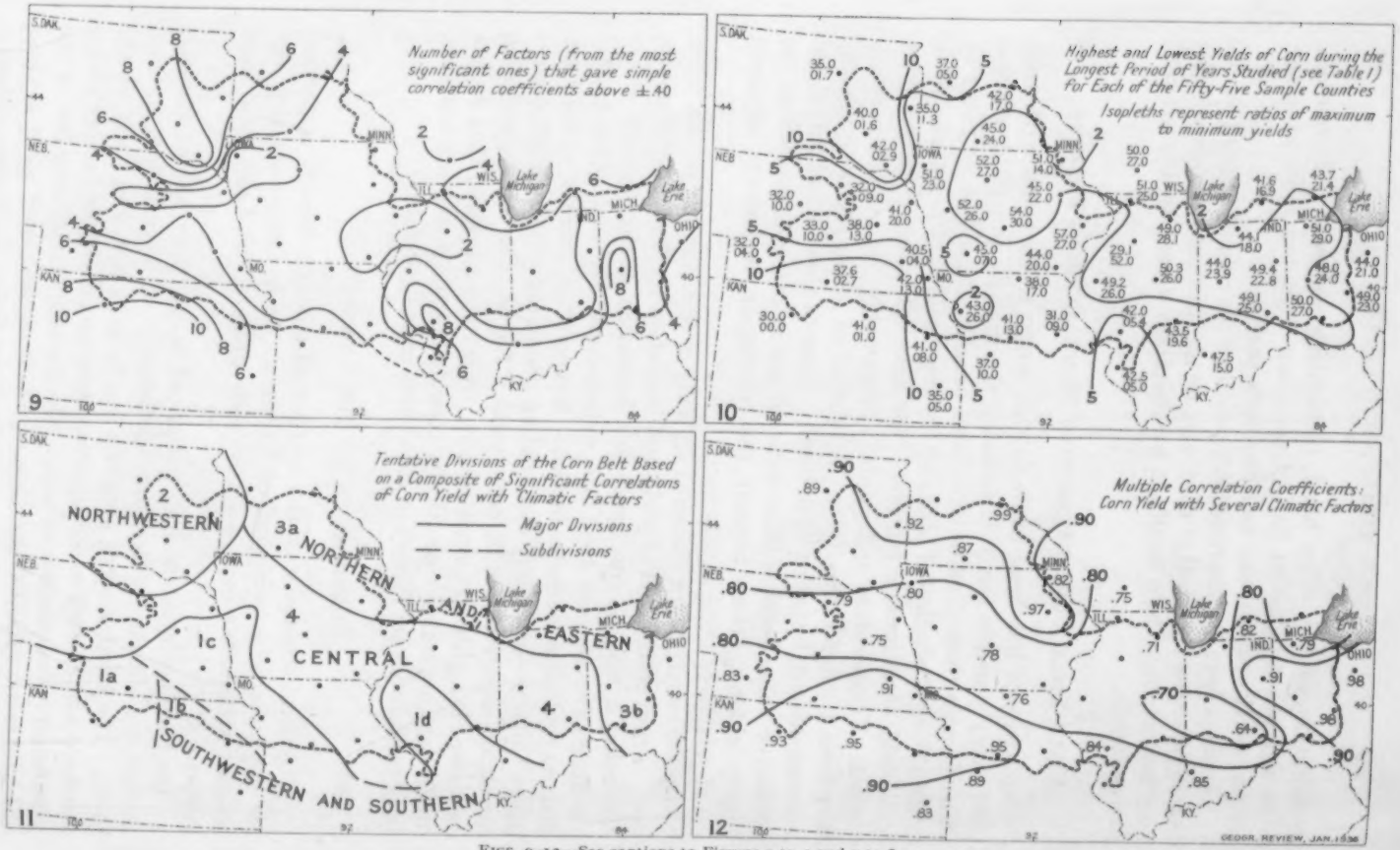
No attempt has been made in this study to correlate with corn yield every possible factor influencing the growth and yield of corn. Other factors than climate have been considered only in an effort to explain the distribution of high and low correlation coefficients between corn yield and climatic factors. Nor have all climatic factors been treated. Temperature and rainfall, presumably the most important, have been treated rather fully. A number of minor factors have also been considered, but with little result. Some of these are of only slight predictive value because basic data for use in computation are as yet largely lacking, others because the correlation coefficients obtained are of relatively little significance.

Insolation data are collected by only a few stations in the Corn Belt. From correlation of yield and insolation for Lancaster County, Nebraska, it may be concluded that insolation in that county either has little effect on corn yield or is so intercorrelated with other factors that its real significance is hidden. Evaporation calculated for Lancaster County—especially evaporation compared with precipitation—correlates negatively with corn yield. For August the correlation coefficient is highly significant (−.78). It is to be regretted that evaporation data are not systematically collected at more weather stations. In general, work on factors of cloudiness gave little return.

Subdivisions of the Corn Belt

A general summary of the number of climatic factors important for any county is presented on Figure 9. Only factors showing significant coefficients over a fairly wide area of the Corn Belt were selected.

On the southwest margin variations in as many as ten climatic factors are shown to correlate significantly with variations in corn yield. The northwestern area has nearly as many, and parts of the southern and eastern marginal areas show no paucity of factors giving significant correlations with yield. On the other hand, very few of the climatic factors studied correlate significantly with corn yield in those samples located near the core of the Corn Belt. In Bureau County, Illinois, not one of the 35 climatic factors or aspects of factors gave a


Number of Factors (from the most significant ones) that gave simple correlation coefficients above ±.40
9
Highest and Lowest Yields of Corn during the Longest Period of Years Studied (see Table 1) for Each of the Fifty-Five Sample Counties
Isopleths represent ratios of maximum to minimum yields
10
Tentative Divisions of the Corn Belt Based on a Composite of Significant Correlations of Corn Yield with Climatic Factors
Major Divisions
Subdivisions
NORTHWESTERN
NORTHERN AND EASTERN
CENTRAL
SOUTHWESTERN AND SOUTHERN
11
Multiple Correlation Coefficients: Corn Yield with Several Climatic Factors
12
GEOGR. REVIEW, JAN. 1936

FIGS. 9–12—See captions to Figures 1 to 4 and 5 to 8.

simple correlation coefficient as high as ±.40. This would seem to indicate that climatic conditions near the optimum for corn yield exist in the heart of the Corn Belt but act increasingly as limiting factors toward the margins.

Near the center of the Corn Belt mean yields are comparatively high, and although yields fluctuate from year to year (see Fig. 10), no one factor by itself seems to have much weight in affecting the yield. On the other hand, near the margins yield seems to depend on a very delicate balance of climatic factors, which fluctuate widely from year to year and are seldom very favorable to high yields. Here numerous climatic factors are significant, and any one of them has relatively great effect on yield.

On the basis of the summary maps (Figs. 4, 5, 6, and 8) Figure 11, showing tentative forecast divisions of the Corn Belt, was prepared. The boundaries on it are not to be regarded as placed exactly or as unchanging; they are merely an attempt to present general divisions of the Corn Belt on the basis of the present study.

In area 1 midseason temperatures are critical, precipitation and early-season temperatures being of importance in some parts. This is the area of the Corn Belt that has the highest temperatures and has at the same time, in parts at least, scanty rainfall. Further to complicate matters, in parts of this area some of the blackerth and chestnuterth soils have a heavy subsoil that lessens water-holding capacity. The mean yield of corn to the acre is low, though the soil can produce good yields during the rare years when climate is favorable (see Fig. 10).

In subarea 1A early-season precipitation is significant and early-season temperatures are highly significant or critical. So many climatic factors are significant and generally unfavorable to corn yield in this area that it is a rare year indeed when yields of 30 bushels or more to an acre are obtained. Complete failure here is not unknown.

In subarea 1B midseason precipitation is highly significant. Yields here fluctuate widely.

To the north and east, in subarea 1C, no precipitation factor gives significant correlations. This may be due to slightly greater humidity, and probably the loess soils have considerable effect.

Factors of minor significance in subarea 1D are early-season temperatures and midseason precipitation, especially for July. Midseason temperatures seem to be not so critical here as in other subdivisions of area 1.

Area 2 is also one in which midseason temperatures and both early-season and midseason precipitation are significant or highly significant. Here the yield of corn to an acre is rather low as compared with the Corn Belt as a whole. Yields vary greatly from year to year (Fig. 10). The fact that all the samples show at least one year when the yield was 35 bushels or more an acre means that the soil can produce if other factors, mainly climatic, permit.

Area 3 is one in which early-season temperatures are critical. Corn in this area needs more heat during planting and the time of early growth. Even so, the average yields are more than 30 bushels an acre, in some counties even more than 35 bushels. This is very largely an area of gray-brownerths, but other areas with the same types of soil give no such correlations.

As regards climatic factors of minor significance, subarea 3A shows almost perfect transition from northwest to southeast. In the northwestern part both mid-

season temperatures and midseason precipitation are significant; in the middle part—northeastern Iowa and northwestern Illinois—only midseason temperatures remain as a factor of minor significance; and in the eastern part there is no minor factor.

In subarea 3B midseason precipitation and midseason temperatures—one or both—are factors of minor significance. Early-season temperatures become less critical to the south but are highly significant near the east margin.

Area 4 is one in which variations in climatic factors do not seem to be critical for corn yield. A variety of factors give significant coefficients, but there is little possibility of generalization regarding climatic factors significant in the area. The westerly protrusion of this area with slightly significant correlations, extending as it does between two areas in which midseason temperatures are critical, is interesting. A suggested hypothesis is that the loess soil found here does not lose its moisture readily even during the hot part of the season, hence the corn plants suffer very little from temperatures that damage the crop severely in areas almost equally humid to the north and south.

The question naturally arises how well it is possible to forecast the yield of corn for the different parts of the Corn Belt. The map of multiple correlation coefficients (Fig. 12) offers summary evidence that in all likelihood corn yields can be very well forecast in the southwest (subareas 1A and 1B), in the northwest (area 2), and in parts of the north and east (area 3). In other parts of the Corn Belt, especially parts of area 4, the coefficients, though helpful, probably will give forecasts containing considerable error.

Conclusions

The correlation of corn yield with climatic factors in the Corn Belt of the United States proves to be a very complex problem, for two reasons. In the first place, climatic variables operate not singly but as many-faceted composites. Secondly, not only climatic factors but other factors of the natural and cultural environment change from area to area. Nevertheless, some climatic factors correlate significantly with corn yield in parts of the Corn Belt. Notable among such factors are precipitation and aspects of temperature for May, June, July, and August. It seems to be an unmistakable conclusion, however, that variation in July rainfall is not everywhere so important a factor in corn yield as earlier investigators believed.

No one climatic factor gives significant correlations for all parts of the Corn Belt; nor, apparently, is any one factor of extreme significance in any part of it. Neither for the Corn Belt as a whole nor for particular areas within it does there seem to be, strictly speaking, such a thing as the critical climatic factor, nor is there much evidence of a critical period. Rather, it seems that corn yield in some parts is to be significantly correlated with several—even ten or more—factors covering much or all of the period of growth and reproduction. In other parts significant correlations with corn yield are found for few or none of the climatic factors investigated.

It does seem that of the factors studied variations in temperature are more significant and more critical to corn yield than are variations in precipitation. Also, the midseason period of growth and reproduction is, on the whole, more critical than the early season, except only in the northeastern part.

In general, the significance of the correlation coefficients between corn yield and the factors of temperature and precipitation decreases from the margins toward the center of the Corn Belt. This is true for all margins except the middle of the west one and is outstandingly true for the southwest and northwest margins. It would seem that the south and east margins, fully as much as the north and west ones, are determined by the fact that climatic factors on the margins do not approximate optimum conditions for high corn yield. On the east margin early-season temperatures are commonly too low; on the south margin early-season temperatures are somewhat too high and mid-season temperatures decidedly too high. This suggests that the rather low yields generally returned by corn planted over wide areas south of the Corn Belt may be due to unfavorable temperature conditions that seemingly cannot be counteracted by any amount of precipitation. Coefficients found for three counties in Texas, Tennessee, and Georgia lend substance to this hypothesis.

On the other hand, corn yield in the center or core of the Corn Belt generally fails to correlate significantly with the climatic factors investigated. This is less true for the coefficients of multiple correlations, in which several factors are considered, than for the coefficients of simple correlations. Presumably corn yield in this core area is somewhat affected by the factors significant on the surrounding margins; but, with several factors operative—perhaps first on one, then on the other, side of the optima, and thus with conditions generally favorable—variation in any one factor has little effect by itself.

In general, the areal distribution pattern of significant simple correlation coefficients between corn yield and individual climatic factors shows discordance in its patterns of such natural factors as soil and altitude. It may be noticed, however, that blackerth, chestnuterth, and gray-brownerth areas show several significant coefficients between corn yield and variations in climatic factors, whereas the prairyerth areas show few significant coefficients. This prairyerth area seems to combine optimum soil and climate for corn yield.

The average date of planting and the average yield of corn show only weak correspondence with the patterns of coefficients found. The areas that most lack heat have in general higher yields than areas adversely affected by high temperatures.

There is in most of the cases not much observable correspondence between the pattern of means or the pattern of standard deviations of a climatic factor and the resulting pattern of simple correlation coeffi-

cients. This seems to be partly because corn yield depends largely on several climatic variables operating simultaneously during most of the period when corn is growing and reproducing.

It should be possible to forecast the yield of corn with a high degree of accuracy for several of the marginal areas of the Corn Belt. The multiple coefficients found for the core of the Corn Belt should be distinctly helpful in forecasting but will not provide the high degree of accuracy presumably attainable for the marginal areas. It seems possible that higher multiple coefficients might be obtained for this area by successive elimination of less significant factors.

The present program of the United States Department of Agriculture calls for a considerable reduction in the acreage devoted to corn. This reduction in acreage has been applied as a blanket project to the whole of the Corn Belt. One way of preventing any undesirable surplus of corn would be to remove from corn production those areas that produce corn least well.

In view of the facts discovered in this study, large parts of areas 1A, 1B, and 2 might well be withdrawn from corn production and devoted to other uses. This suggestion is based chiefly on the fact that corn yield in these areas, especially in areas 1A and 2, is commonly so adversely affected in a critical manner by several climatic factors as to be well below the average for the United States as a whole and far below the average for the Corn Belt as a whole. Moreover, these two areas are included in the region where wind erosion is especially damaging to soil resources, and cornland is badly exposed to such erosion. The remainder of the Corn Belt can produce, on the average, as much corn as is now needed.

Finally, the areas for which significant correlation coefficients, for either individual factors or groups of factors, were discovered in this study show no respect for state boundaries. It seems, therefore, that the use of sample counties rather than of state averages gives a more informative solution of the problem, especially those aspects of it that relate to areal variations. Not only sampling but also correlation analysis seems well adapted to this problem and, with modifications, to a wide range of geographical problems.

A METHOD OF MAPPING DENSITIES OF POPULATION

WITH CAPE COD AS AN EXAMPLE

John K. Wright

THE first of the maps presented on page 105 is a conventional population map of Cape Cod in which a symbol for the density covers the whole area of each township. The map is not particularly realistic. Anyone who has visited the region knows that large parts of it are uninhabited. Terminal-moraine ridges run parallel to the north and east shores of the Cape's "upper arm"—to use a term implying comparison of the Cape to an arm shaking its fist at the Atlantic. These moraines are wildernesses of burnt-over land covered with scrub oak and stunted pine. Fringing Nantucket Sound is a string of villages, but elsewhere the sandy outwash plains that intervene between the moraines and the sound are thinly peopled, and one often drives for several miles without seeing a house. At the tip end of the Cape the map shows a density of 200 to 500 to the square mile in the "fist." As a matter of fact, nearly all the people here live in the compact village of Provincetown along the harbor, and the greater part of the "fist" consists of sand dunes, where the density actually approaches zero. Most of this tract of dunes is maintained by the state as a reservation known as the Province Lands, where the vegetation is carefully fostered in order to prevent the sands from overwhelming the village. Figure 1 gives no idea whatever of these local differences.

On Figure 2 "uninhabited" areas have been marked off and densities calculated and plotted for the remaining parts of each township in which such areas occur. Just what is an uninhabited area? Conceivably on a map of extremely large scale one might classify one's back yard in this category. On the other hand, if all areas that people enter or cross from time to time are held to be inhabited, no part of the Cape could properly be regarded as uninhabited, for even the wildest parts are visited each year by hunters, berrypickers, forest wardens, or fire fighters.

The areas shown as "uninhabited" on Figure 2 are, in general, either wastelands not in farms or areas occupied only part of the year by summer residents. They were determined in a rough-and-ready manner from an examination of the topographic sheets of the U. S. Geological Survey supplemented by personal recollections. Obviously their outlines are not precise, but, even so, everyone will concede that Figure 2 is a more realistic density map than Figure 1.

Similar rough-and-ready methods of mapping have been carried

a stage further on Figure 3. Here an attempt has been made to divide the inhabited areas within each township into tracts of different densities. In view of the fact that no population statistics exist for tracts smaller than townships on the Cape, Figure 3 is based largely on guesswork. As will be explained, however, it is what might be called "controlled guesswork," and the picture is certainly more realistic—more truly geographical—than that furnished by either Figure 1 or Figure 2. Perhaps it is about the best that could be accomplished without intensive field work. Figure 3 is based on "the premise that the distribution of population is not a phenomenon of uninterrupted, continuous gradation and hence is not properly portrayed by a system involving isopleths, as are portrayed such gradational phenomena as slope in topography or gradient in climatology."[1] It is a map of the type to which the Russians have applied the term "dasymetric" (density measuring).[2]

Another method by which the distribution of population within the townships could have been shown is the well known dot method. In this method the total population of each township determines the number of dots to be placed within its limits. On the basis of available evidence—topographic maps, field observations, etc.—the dots may be distributed so as to conform to what is believed to be the actual distribution of the people. This method, however, is hardly more precise than the method used on Figure 3. On a dot map thus constructed, although the total number of dots to a township may be statistically correct, individual dots do not necessarily represent the exact population of the areas where they are placed. Similarly, on Figure 3 the several densities assigned to the different parts of each township are consistent with the known density of the township as a whole (i.e. the density as shown on Figure 1), though the individual density assigned to any given area may be inexact.

Such a map has one advantage over a dot map. It provides definite figures to which one may refer. For example, with reference to Figure 3 one may write: "The map shows that the northeastern part of the township of Falmouth has a density of 5 to 19 to the square mile, whereas densities in excess of 200 to the square mile prevail over the southern part of the township." With a dot map one can merely state in vague terms that the dots are much more thickly clustered in the southern part of the township than in the northeastern part.[3]

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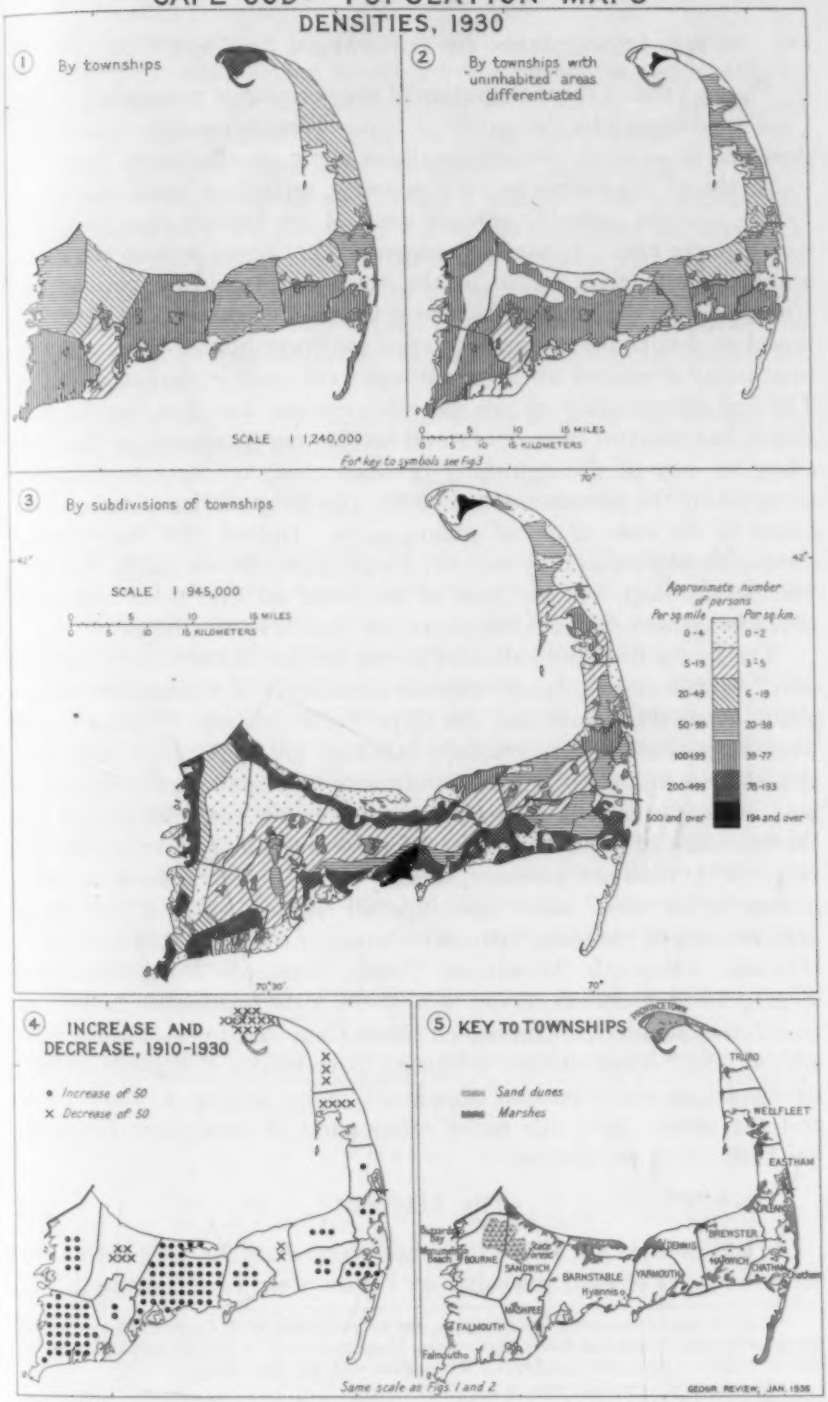
[1] W. L. G. Joerg: Research Problems in Natural Science Bearing on National Land Planning, *in* Second Report of the Science Advisory Board, September 1, 1934 to August 31, 1935, Washington, 1935, pp. 375–394; reference on p. 391.

[2] A map of this type showing the distribution of population in New England, 1930 (scale: 1 : 3,000,000), will be found in "New England's Prospect: 1933," *Amer. Geogr. Soc. Special Publ. No. 16*, 1933, pp. 22–23.

[3] The relative merits of dot maps and shaded maps formed the subject of discussion at a meeting at the Royal Geographical Society in 1934. See "Population Maps: A Discussion . . . . Opened by Professor C. B. Fawcett," *Geogr. Journ.*, Vol. 85, 1935, pp. 142–159.



FIGS. 1–5—Four population maps of Cape Cod and a key map. The density maps are explained in the text

The Distribution of Population on Cape Cod

Figure 3 shows the distribution of the permanent population of the Cape as indicated by the census of 1930. Were it possible to map the densities in summer, certain localities along the Buzzards Bay and south shores appearing as very sparsely settled or uninhabited on Figure 3 would probably contain some of the highest densities anywhere on the map. It has been suggested that house dots on the topographic sheets give a clue to the arrangement of the population. Unfortunately the topographic sheets for the Cape are not particularly useful in this respect because they show fewer houses than actually exist today or existed when the surveys were made in the late eighties. The Soil Survey map[4] shows more house dots than the topographic sheets, but many of these dots stand for summer cottages, and the map offers no way of distinguishing between these cottages and houses occupied by the permanent residents. The same difficulty, moreover, exists in the case of aerial photographs. Indeed, the topographic sheets, incomplete as they may be, are perhaps a better guide than the Soil Survey map, because most of the house dots on them represent the older centers—the centers where the "natives" now reside.

The sparse densities indicated in the interior of the Cape's "upper arm" represent to a large extent a population of Portuguese immigrants from the Azores and the Cape Verde Islands. "These hard-working peasant folk successfully cultivate cranberry bogs and raise strawberries and vegetables on sandy soils that had long been avoided by Yankee farmers."[5] Their presence probably accounts in part for the increases in population that have occurred in certain townships (Fig. 4). It does not, however, furnish the entire explanation of these increases; for these same townships all contain villages that have become popular shopping centers for summer residents and tourists—Hyannis, Falmouth, Monument Beach, Buzzards Bay, Chatham. This fact has doubtless served to hold the local population as well as to attract outsiders. The barren outer Cape has fewer Portuguese, and, although many summer people go there, no one of the villages has developed as an important shopping center serving a large area, and the outer Cape, like many other parts of rural New England, has been losing population.

The Method[6]

It was pointed out above that the several densities assigned to the different parts of each township on Figure 3 are consistent with the

[4] Colored map of Barnstable County (1 : 62,500) accompanying W. J. Latimer and others: Soil Survey of Norfolk, Bristol, and Barnstable Counties, Massachusetts, *U. S. Dept. of Agric., Field Operations of the Bur. of Soils, 1920 (22nd Rept.)*, Washington, 1925, pp. 1033–1120.

[5] New England's Prospect: 1933. p. 32.

[6] The writer is indebted to Mr. O. M. Miller of the American Geographical Society for valuable suggestions concerning this section of the paper.

known average density for the township as a whole. Assume, for example, a township with a known average density of 100 persons to the square mile. Assume, further, that examination of topographic maps and consideration of other evidence have shown that this township may be divided into two parts, *m*, comprising 0.8 of the entire area of the township and having a relatively sparse population, and *n*, comprising the remaining 0.2 of the township and having a relatively dense population. If, then, we estimate that the density of population in *m* is 10 persons to the square mile, a density of 460 to the square mile must be assigned to *n* in order that the estimated densities *m* and *n* may be consistent with 100, the average density for the township as a whole.

The figure 460 for the density in *n* was obtained by solving the following fundamental equation:[7]

$$\frac{D - D_m a_m}{1 - a_m} = D_n \quad \text{or} \quad \frac{100 - 10\,(0.8)}{0.2} = 460,$$

where D is the average density of population of the township as a whole, D_m the estimated density in *m*, a_m the fraction of the total area of the township comprised in *m*, $1 - a_m$ the fraction comprised in *n*, and D_n the density that must accordingly be assigned to *n*.

D_m and a_m are estimated approximately. It is not necessary to measure a_m accurately, since the margin of error in a rough estimate is likely to be less than the margin of error in the best possible estimate of D_m. Study of neighboring townships sometimes gives a clue to a value that may reasonably be assigned to D_m. For example, the topographic map may show what would appear to be similar types of population distribution prevailing over T_m, or part of one township, and over the whole of S, an adjacent township. It would be reasonable, therefore, to assign to T_m a density comparable with the average density in S.

Having assigned estimated but consistent densities to two parts

[7] This equation is established thus: Let P and A represent the population and area (in square miles or square kilometers) respectively of the whole township; *m* and *n*, two subdivisions of the township that together constitute the whole township; P_m and A_m, P_n and A_n, the population and area of *m* and *n* respectively; and p_m, a_m, p_n, and a_n, the fractions of P and of A in *m* and *n* respectively.

Obviously: $D = \frac{P}{A}$, $D_m = \frac{P_m}{A_m}$, $P_m = Pp_m$, $A_m = Aa_m$, $a_n = 1 - a_m$, $p_n = 1 - p_m$

Hence: $D_m = \frac{Pp_m}{Aa_m} = D\frac{p_m}{a_m}$ and $p_m = \frac{D_m a_m}{D}$. Similarly: $D_n = \frac{Dp_n}{a_n} = \frac{D(1 - p_m)}{(1 - a_m)}$ (1)

Substituting $\frac{D_m a_m}{D}$ for p_m in (1): (2)

$$D_n = \frac{D\left\{1 - \frac{D_m a_m}{D}\right\}}{1 - a_m} = \frac{D - D_m a_m}{1 - a_m}$$

TABLE I—TABULAR AID TO CONSISTENCY IN ESTIMATING DENSITIES OF POPULATION

D OR D_m	a_m 0.1		0.2		0.3		0.4		0.5		0.6		0.7		0.8		0.9		D OR D_m
	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	
	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	
1	1	0.1	1	0.3	1	0.4	2	0.7	2	1	2	1.5	3	2.3	5	4	10	9	1
2	2	0.2	3	0.5	3	0.9	3	1.3	4	2	5	3.0	7	4.7	10	8	20	18	2
3	3	0.3	4	0.8	4	1.3	5	2.0	6	3	7	4.5	10	7.0	15	12	30	27	3
4	4	0.4	5	1.0	6	1.8	7	2.7	8	4	10	6.0	13	9.3	20	16	40	36	4
5	6	0.6	6	1.3	7	2.2	8	3.3	10	5	12	7.5	17	11.7	25	20	50	45	5
6	7	0.7	8	1.5	9	2.7	10	4.0	12	6	15	9.0	20	14.0	30	24	60	54	6
7	8	0.8	9	1.8	10	3.1	12	4.7	14	7	17	10.5	23	16.3	35	28	70	63	7
8	9	0.9	10	2.0	12	3.6	13	5.3	16	8	20	12.0	27	18.6	40	32	80	72	8
9	10	1.0	11	2.3	13	4.0	15	6.0	18	9	22	13.5	30	21.0	45	36	90	81	9
10	11	1.1	13	2.5	14	4.4	17	6.7	20	10	25	15.0	33	23.3	50	40	100	90	10
11	12	1.2	14	2.8	16	4.9	18	7.3	22	11	27	16.5	37	25.6	55	44	110	99	11
12	13	1.3	15	3.0	17	5.3	20	8.0	24	12	30	18.0	40	28.0	60	48	120	108	12
13	14	1.4	16	3.3	19	5.8	22	8.7	26	13	32	19.5	43	30.3	65	52	130	117	13
14	16	1.6	18	3.5	20	6.2	23	9.3	28	14	35	21.0	47	32.6	70	56	140	126	14
15	17	1.7	19	3.8	22	6.7	25	10.0	30	15	37	22.5	50	35.0	75	60	150	135	15
16	18	1.8	20	4.0	23	7.1	27	10.7	32	16	40	24.0	53	37.3	80	64	160	144	16
17	19	1.9	21	4.3	24	7.5	28	11.3	34	17	42	25.5	57	39.6	85	68	170	153	17
18	20	2.0	23	4.5	26	8.0	30	12.0	36	18	45	27.0	60	41.9	90	72	180	162	18
19	21	2.1	24	4.8	27	8.4	32	12.7	38	19	47	28.5	63	44.3	95	76	190	171	19
20	22	2.2	25	5.0	29	8.9	33	13.3	40	20	50	30.0	67	46.6	100	80	200	180	20
21	23	2.3	26	5.3	30	9.3	35	14.0	42	21	52	31.5	70	48.9	105	84	210	189	21
22	24	2.4	28	5.5	32	9.8	37	14.7	44	22	55	33.0	73	51.3	110	88	220	198	22
23	26	2.6	29	5.8	33	10.2	38	15.3	46	23	57	34.5	77	53.6	115	92	230	207	23
24	27	2.7	30	6.0	35	10.7	40	16.0	48	24	60	36.0	80	55.9	120	96	240	216	24
25	28	2.8	31	6.3	36	11.1	42	16.7	50	25	62	37.5	83	58.3	125	100	250	225	25
26	29	2.9	33	6.5	37	11.5	43	17.3	52	26	65	39.0	87	60.6	130	104	260	234	26
27	30	3.0	34	6.8	39	12.0	45	18.0	54	27	67	40.5	90	62.9	135	108	270	243	27
28	31	3.1	35	7.0	40	12.4	46	18.6	56	28	70	42.0	93	65.2	140	112	280	252	28
29	32	3.2	36	7.3	42	12.9	48	19.3	58	29	72	43.5	97	67.6	145	116	290	261	29
30	33	3.3	38	7.5	43	13.3	50	20.0	60	30	75	45.0	100	69.9	150	120	300	270	30
31	34	3.4	39	7.8	45	13.8	51	20.6	62	31	77	46.5	103	72.2	155	124	310	279	31
32	36	3.6	40	8.0	46	14.2	53	21.3	64	32	80	48.0	107	74.6	160	128	320	288	32
33	37	3.7	41	8.3	48	14.7	55	22.0	66	33	82	49.5	110	76.9	165	132	330	297	33
34	38	3.8	43	8.5	49	15.1	56	22.6	68	34	85	51.0	113	79.2	170	136	340	306	34
35	39	3.9	44	8.8	50	15.5	58	23.3	70	35	87	52.5	117	81.6	175	140	350	315	35
36	40	4.0	45	9.0	52	16.0	60	24.0	72	36	90	54.0	120	83.9	180	144	360	324	36
37	41	4.1	46	9.3	53	16.4	61	24.6	74	37	92	55.5	123	86.2	185	148	370	333	37
38	42	4.2	48	9.5	55	16.9	63	25.3	76	38	95	57.0	127	88.5	190	152	380	342	38
39	43	4.3	49	9.8	56	17.3	65	26.0	78	39	97	58.5	130	90.9	195	156	390	351	39
40	44	4.4	50	10.0	58	17.8	66	26.6	80	40	100	60.0	133	93.2	200	160	400	360	40
41	46	4.6	51	10.3	59	18.2	68	27.3	82	41	102	61.5	137	95.5	205	164	410	369	41
42	47	4.7	53	10.5	60	18.6	70	28.0	84	42	105	63.0	140	97.9	210	168	420	378	42
43	48	4.8	54	10.8	62	19.1	71	28.6	86	43	107	64.5	143	100.2	215	172	430	387	43
44	49	4.9	55	11.0	63	19.5	73	29.3	88	44	110	66.0	147	102.5	220	176	440	396	44
45	50	5.0	56	11.3	65	20.0	75	30.0	90	45	112	67.5	150	104.9	225	180	450	405	45
46	51	5.1	58	11.5	66	20.4	76	30.6	92	46	115	69.0	153	107.2	230	184	460	414	46
47	52	5.2	59	11.8	68	20.9	78	31.3	94	47	117	70.5	157	109.5	235	188	470	423	47
48	53	5.3	60	12.0	69	21.3	80	32.0	96	48	120	72.0	160	111.8	240	192	480	432	48
49	54	5.4	61	12.3	71	21.8	81	32.6	98	49	122	73.5	163	114.2	245	196	490	441	49

D or D_m	a_m 0.1		0.2		0.3		0.4		0.5		0.6		0.7		0.8		0.9		D or D_m
	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	D	$D_m a_m$	
	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	$1-a_m$	
50	56	5.6	63	12.5	72	22.2	83	33.3	100	50	125	75.0	167	116.5	250	200	500	450	50
51	57	5.7	64	12.8	73	22.6	85	34.0	102	51	127	76.5	170	118.8	255	204	510	459	51
52	58	5.8	65	13.0	75	23.1	86	34.6	104	52	130	78.0	173	121.2	260	208	520	468	52
53	59	5.9	66	13.3	76	23.5	88	35.3	106	53	132	79.5	177	123.5	265	212	530	477	53
54	60	6.0	68	13.5	78	24.0	90	36.0	108	54	135	81.0	180	125.8	270	216	540	486	54
55	61	6.1	69	13.8	79	24.4	91	36.6	110	55	137	82.5	183	128.2	275	220	550	495	55
56	62	6.2	70	14.0	81	24.9	93	37.3	112	56	140	84.0	187	130.5	280	224	560	504	56
57	63	6.3	71	14.3	82	25.3	95	38.0	114	57	142	85.5	190	132.8	285	228	570	513	57
58	64	6.4	73	14.5	84	25.8	96	38.6	116	58	145	87.0	193	135.1	290	232	580	522	58
59	65	6.5	74	14.8	85	26.2	98	39.3	118	59	147	88.5	197	137.5	295	236	590	531	59
60	67	6.7	75	15.0	86	26.6	100	40.0	120	60	150	90.0	200	139.8	300	240	600	540	60
61	68	6.8	76	15.3	88	27.1	101	40.6	122	61	152	91.5	203	142.1	305	244	610	549	61
62	69	6.9	78	15.5	89	27.5	103	41.3	124	62	155	93.0	207	144.5	310	248	620	558	62
63	70	7.0	79	15.8	91	28.0	105	42.0	126	63	157	94.5	210	146.8	315	252	630	567	63
64	71	7.1	80	16.0	92	28.4	106	42.6	128	64	160	96.0	213	149.1	320	256	640	576	64
65	72	7.2	81	16.3	94	28.9	108	43.3	130	65	162	97.5	217	151.5	325	260	650	585	65
66	73	7.3	83	16.5	95	29.3	110	44.0	132	66	165	99.0	220	153.8	330	264	660	594	66
67	74	7.4	84	16.8	96	29.7	111	44.6	134	67	167	100.5	223	156.1	335	268	670	603	67
68	75	7.5	85	17.0	98	30.2	113	45.3	136	68	170	102.0	227	158.4	340	272	680	612	68
69	77	7.7	86	17.3	99	30.6	115	46.0	138	69	172	103.5	230	160.8	345	276	690	621	69
70	78	7.8	88	17.5	101	31.1	116	46.6	140	70	175	105.0	233	163.1	350	280	700	630	70
71	79	7.9	89	17.8	102	31.5	118	47.3	142	71	177	106.5	237	165.4	355	284	710	639	71
72	80	8.0	90	18.0	104	32.0	120	48.0	144	72	180	108.0	240	167.8	360	288	720	648	72
73	81	8.1	91	18.3	105	32.4	121	48.6	146	73	182	109.5	243	170.1	365	292	730	657	73
74	82	8.2	93	18.5	107	32.9	123	49.3	148	74	185	111.0	247	172.4	370	296	740	666	74
75	83	8.3	94	18.8	108	33.3	125	50.0	150	75	187	112.5	250	174.8	375	300	750	675	75
76	84	8.4	95	19.0	109	33.7	126	50.6	152	76	190	114.0	253	177.1	380	304	760	684	76
77	85	8.5	96	19.3	111	34.2	128	51.3	154	77	192	115.5	257	179.4	385	308	770	693	77
78	87	8.7	98	19.5	112	34.6	129	51.9	156	78	195	117.0	260	181.7	390	312	780	702	78
79	88	8.8	99	19.8	114	35.1	131	52.6	158	79	197	118.5	263	184.1	395	316	790	711	79
80	89	8.9	100	20.0	115	35.5	133	53.3	160	80	200	120.0	267	186.4	400	320	800	720	80
81	90	9.0	101	20.3	117	36.0	134	53.9	162	81	202	121.5	270	188.7	405	324	810	729	81
82	91	9.1	103	20.5	118	36.4	136	54.6	164	82	205	123.0	273	191.1	410	328	820	738	82
83	92	9.2	104	20.8	120	36.9	138	55.3	166	83	207	124.5	277	193.4	415	332	830	747	83
84	93	9.3	105	21.0	121	37.3	139	55.9	168	84	210	126.0	280	195.7	420	336	840	756	84
85	94	9.4	106	21.3	122	37.7	141	56.6	170	85	212	127.5	283	198.1	425	340	850	765	85
86	95	9.5	108	21.5	124	38.2	143	57.3	172	86	215	129.0	287	200.4	430	344	860	774	86
87	97	9.7	109	21.8	125	38.6	144	57.9	174	87	217	130.5	290	202.7	435	348	870	783	87
88	98	9.8	110	22.0	127	39.1	146	58.6	176	88	220	132.0	293	205.0	440	352	880	792	88
89	99	9.9	111	22.3	128	39.5	148	59.3	178	89	222	133.5	297	207.4	445	356	890	801	89
90	100	10.0	113	22.5	130	40.0	149	59.9	180	90	225	135.0	300	209.7	450	360	900	810	90
91	101	10.1	114	22.8	131	40.4	151	60.6	182	91	227	136.5	303	212.0	455	364	910	819	91
92	102	10.2	115	23.0	132	40.8	153	61.3	184	92	230	138.0	307	214.4	460	368	920	828	92
93	103	10.3	116	23.3	134	41.3	154	61.9	186	93	232	139.5	310	216.7	465	372	930	837	93
94	104	10.4	118	23.5	135	41.7	156	62.6	188	94	235	141.0	313	219.0	470	376	940	846	94
95	105	10.5	119	23.8	137	42.2	158	63.3	190	95	237	142.5	317	221.4	475	380	950	855	95
96	107	10.7	120	24.0	138	42.6	159	63.9	192	96	240	144.0	320	223.7	480	384	960	864	96
97	108	10.8	121	24.3	140	43.1	161	64.6	194	97	242	145.5	323	226.0	485	388	970	873	97
98	109	10.9	123	24.5	141	43.5	163	65.3	196	98	245	147.0	327	228.3	490	392	980	882	98
99	110	11.0	124	24.8	143	44.0	164	65.9	198	99	247	148.5	330	230.7	495	396	990	891	99
100	111	11.1	125	25.0	144	44.4	166	66.6	200	100	250	150.0	333	233.0	500	400	1000	900	100

of a township, one may then divide each (or one) of these parts into two subdivisions and work out densities for the latter in the same manner; and the process may be repeated within each subdivision. Figure 3 was prepared in this manner.

The method is merely an aid to consistency in apportioning estimated densities, either of population or of other phenomena, within the limits of townships or other territorial units for whose subdivisions no statistical data are available. Obviously it should not be applied in mapping densities of population within counties in the United States, since census figures are published for the townships and other minor civil divisions within the counties. On the other hand, it might well be applied in mapping various phenomena for which statistics are available by counties but not by minor civil divisions.

Table I enables one to solve the fundamental equation without either multiplication or division. This equation may be written

$$D_n = \frac{D}{1 - a_m} - \frac{D_m a_m}{1 - a_m}.$$

Values of $\frac{D}{1 - a_m}$ and $\frac{D_m a_m}{1 - a_m}$ may be extracted from the table as follows. The table is entered at the top with a_m and entered at the side with D or D_m as arguments. When D is the argument, the left-hand column under the particular value of a_m gives values of $\frac{D}{1 - a_m}$. When D_m is the argument, the right-hand column under the particular value of a_m gives values of $\frac{D_m a_m}{1 - a_m}$.

In order to obtain D_n, subtract the value obtained from entering the table with D_m as argument from the value obtained from entering the table with D as argument. (If this value is a minus quantity, then the value of D_m is too large to be consistent with the values of D and of a_m.)

For example: $D = 100$, $D_m = 10$, $a_m = 0.8$.

From row 100 and left-hand column under 0.8 extract value 500; from row 10 and right-hand column under 0.8 extract value 40; $500 - 40 = 460 = D_n$.

FOG IN THE UNITED STATES AND ADJACENT REGIONS*

Robert G. Stone

Blue Hill Observatory, Harvard University

"SILENT in its formation and disappearance, unaccompanied by violent atmospheric disturbances of any sort, associated with no brilliant optical phenomena, suggesting no startling world-wide human responses—fog nevertheless has many important relations to the life of man." With these words the late Professor R. DeC. Ward began a paper on "Fog in the United States" that was published in this journal in 1923.[1] He then went on to point out some of the effects of fog on men's activities, health, and comfort. He mentioned especially the menace of fog to navigation by water and transportation by land. During the thirteen years that have passed since Ward's article appeared the phenomenal growth of air travel has aroused added interest in fog and the problem of circumventing it; and the need has arisen for yet more comprehensive investigations of the distribution and characteristics of this widespread phenomenon.

The present paper is essentially an explanation and interpretation of the data appearing on the accompanying maps and graphs. A critical discussion of the information on which these illustrations are based and of their adequacy and accuracy will be found in Appendix I on pages 124–127, below.

Figure 1 shows the generalized distribution of fog in the United States and adjacent territory as far as indicated, for the most part, by the *mean annual number of days with "dense" fog.* This map differs in some significant details from that published by Kincer in 1922,[2] which was based on only 20-year means and a much sparser net of stations. However, the general pattern, being the same on both maps, must be regarded as well established. In drawing the isopleths for Figure 1 much qualitative information was used; the length and

*This paper is part of a larger study of fog distribution that the author has been carrying on since 1932; during the past year it has been continued in part under the auspices and support of the Blue Hill Observatory of Harvard University. The author is much indebted to Dr. Charles F. Brooks, director of the Blue Hill Observatory, and to Professor H. C. Willett of the Massachusetts Institute of Technology for having read the manuscript at various stages and for many helpful criticisms and suggestions; to Mr. A. J. Connor of the Meteorological Service of Canada for supplying certain data; and to the many U. S. Weather Bureau officials who have generously supplied him with data and other information. The author, however, assumes all responsibility for any facts or conclusions presented.

[1] *Geogr. Rev.*, Vol. 13, 1923, pp. 576–582.

[2] J. B. Kincer: Atlas of American Agriculture, Part II, Climate, Sect. A, Precipitation and Humidity, U. S. Dept. of Agriculture, Washington, 1922, Fig. 82, p. 44. This map is reproduced by Ward, *op. cit.*, p. 577, and in his "The Climates of the United States," Boston, etc., 1925, p. 305. In these two publications Ward gives a good general introduction to the distribution of fog in the United States. A still more detailed treatment is that of V. E. Jakl: Fog, *in* Aeronautical Meteorology, by W. R. Gregg and others, 2nd edit., New York, 1930, pp. 117–146. There is a large literature on fog in the United States, but except for a few recent studies along modern meteorological lines it contains much that is misleading or incorrect.

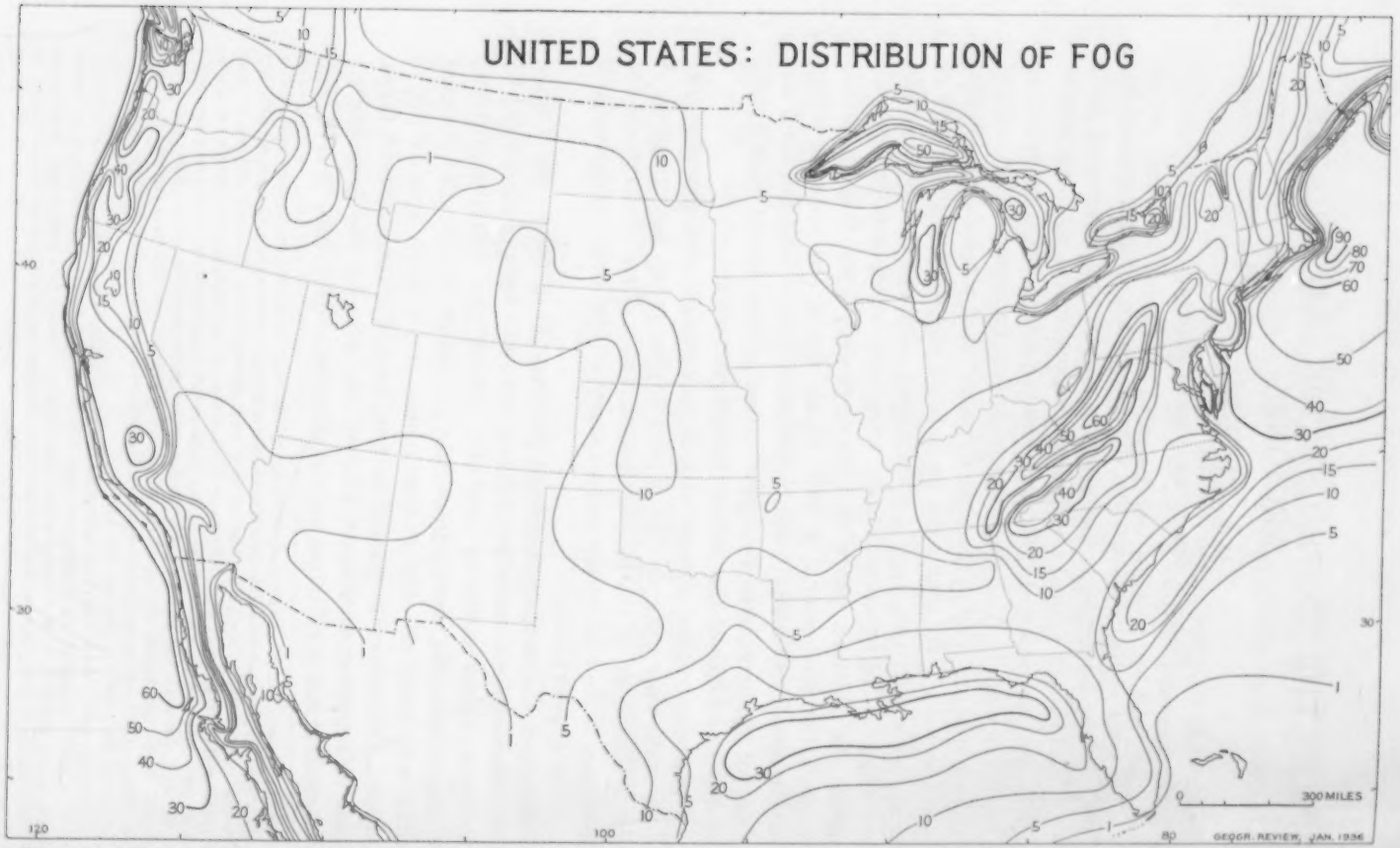


FIG. 1—Map showing distribution of fog in the United States. The isopleths show the mean annual number of days with "dense fog, i.e. fogs obscuring the visibility to 1000 feet or less." In order to bring out more detail in the large portion of the country where the fogginess is less than 20 days, an interval of 5 days was selected. For regions with more than 20 days of fog a 10-day interval is used, because of the steepness of the gradients. Scale of map approximately 1 : 24,000,000.

reliability of the station records, the influence of topography, water bodies, and other factors were considered as far as possible. The picture thereby comes nearer the truth than would a purely mechanical interpretation of the data.

As a basis for Figure 4 (p. 128), showing distribution of fog regimes, the march of mean fogginess from month to month through the year was plotted for every station, and the curves were classified into recurring types, differentiated primarily by the seasons or months of maxima and minima and the shapes of the curves. A large number of more or less distinct types appear, each peculiar to a certain region. Fog regimes generally differ from rainfall and temperature regimes in that curves for individual stations of the same regime type often vary greatly in amplitude or in general level of frequency values. Typical curves for most of the types are presented in Figures 2 and 3; the geographical domain of each type and of many of the varieties is outlined on Figure 4.

After the types were distinguished on statistical and areal bases, a physical explanation for each was sought. The meteorological causes of the different regimes are complex, and at present they are only imperfectly understood, though much may be inferred regarding them. In providing a rational interpretation a grouping of the types and subtypes into genetically related hierarchies was evolved. Owing to lack of space only an outline of the types and their relations is presented here, the details of local peculiarities and causes being reserved for more extensive discussions elsewhere. The outstanding characteristics of each of the larger groups of regimes—Oceanic, Continental, Littoral and Great Lakes—are explained in the paragraphs that immediately follow. A more detailed classification of the regimes will be found in Appendix II on pages 127–134, below.

The Oceanic Regimes

Over the open oceans poleward of the trade winds the characteristic regime is a nearly regular curve having a summer maximum and a winter minimum. There are many local and regional varieties, however, particularly near the coasts and over bays and protected seas. This type of regime results almost entirely from *advection fogs*[3] caused

[3] This term and all others used in this paper to indicate a meteorological type or cause of fog are, if italicized, used in the particular senses given them by H. C. Willett in his classic and indispensable paper on "Fog and Haze, Their Causes, Distribution, and Forecasting," *Monthly Weather Rev.*, Vol. 56, 1928, pp. 435–468. Such terms, when not italicized, are used either in senses defined by the author herein or else in senses generally understood before the appearance of Willett's paper or given by the older texts. Willett has amplified his ideas with reference to the eastern United States in a later paper, "Synoptic Studies in Fog," *Meteorol. Papers, Mass. Inst. of Technology*, Vol. 1, No. 1, 1930. The brilliant work of Willett has placed the causes and classification of fog on the advanced rational basis of the dynamic concepts of the Norwegian school of meteorology; the discussion of fog distribution in the present paper is not altogether intelligible without some understanding of the kinds and causes of fogs from that point of view. The difficulty with fog classification in practice, no matter how excellent the scheme, is that in many cases several causes are working together at the same time to produce the fog;

feet or less." In order to bring out more detail in the large portion of the country where the fogginess is less than 20 days, an interval of 5 days was selected. For regions with more than 20 days of fog a 10-day interval is used, because of the steepness of the gradients. Scale of map approximately 1:24,000,000.

by differences between the surface temperatures of air and water. In general the amount of fogginess is proportionate to the negative thermal anomaly of the water surface temperature; thus the foggiest belts occur when and where the waters are coldest for the latitude.[4] This effect is greatly increased over water currents that are abnormally cold for the latitude and upwell near, or run closely parallel to, warm water currents or areas. The same is true where warm, moist air currents are carried over colder water by the westerly atmospheric drift or cyclonic winds flowing from land masses, as in summer in middle latitudes.

However, outside any anomalously cold coastal currents the steepness of the poleward surface-temperature gradient largely determines the latitudinal intensity and limits of the summer *advection fog* belt of the ocean, at least in so far as cyclonic circulations transport air masses poleward through great distances.

Warm air over cold water is much more prolific as a fog producer (*monsoon fog*, *sea fog*, *Tropical air fog*[5]) than the reverse, and as warm air over cold water occurs more frequently and with greater intensity in the warmer half of the year, the summer fog maximum is the general result. Cold air over warmer water is chiefly a winter phenomenon, and because it is thermodynamically an unstable condition and the difference in temperature must be great, it does not often produce widespread dense fog (steam fogs: *Arctic sea smoke*, *steam mist*, or "vapor").

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this should be kept in mind. For an understanding of the practical significance of the fog statistics it is necessary to know the meteorological kinds of fogs involved, because each kind has its characteristic form of density, extent, persistence, time of day, depth, relation to topography, etc. A knowledge of the regime and the kinds of fogs producing it is likely to be of use to the forecaster. Descriptive vernacular terms are used in quotes.

[4] The local upwelling of cold bottom waters over shoals, in straits, and along the coasts (by tidal stirring and currents and with offshore or along-shore winds) often causes local fog banks or "fog holes" (cf. F. W. Proctor: A Study of the Summer Fogs of Buzzards Bay, *Monthly Weather Rev.*, Vol. 31, 1903, pp. 467–472). From a careful study of the relations of fogginess to actual water temperatures and to the regimes of air-water temperature differences, with due regard for the wind system and air masses also, fairly accurate inferences about the fog regime where no data are available may generally be made. The surface-temperature phenomena of the Atlantic coastal waters have been especially well studied by H. B. Bigelow (Physical Oceanography of the Gulf of Maine, *U. S. Bur. of Fisheries Doc. No. 969*, 1927, pp. 543–563, 668–673, and 679–699; Studies of the Waters on the Continental Shelf, Cape Cod to Chesapeake Bay: I, The Cycle of Temperature, *Papers in Physical Oceanogr. and Meteorol., Mass. Inst. of Technology and Woods Hole Oceanogr. Instn.*, Vol. 2, No. 4, 1933); for the North Atlantic as a whole see W. F. McDonald: Seasonal Variation in North Atlantic Surface-Temperatures, *Trans Amer. Geophys. Union, Sixteenth Ann. Meeting, April 25 and 26, 1935*, Washington, 1935, Part I, pp. 228–239. For the Pacific coastal water temperatures see references in footnotes 30 and 31; J. Patterson: Water Temperatures on the Pacific and Their Effect on the Weather of Canada, *Proc. 5th Pacific Sci. Congr., Canada, 1933*, Vol. 3, Toronto, 1934, pp. 1775–1783; and T. G. Thompson and R. J. Robinson: The Sea Water of the Puget Sound Region, *ibid.*, pp. 2101–2107. For the Gulf of Mexico and Florida-Bermuda region see W. F. McDonald and A. K. Showalter: Air- and Water-Temperatures in the West Indian Region, *Trans. Amer. Geophys. Union, Fourteenth Ann. Meeting, April 27, 28, 29, 1933*, Washington, 1933, pp. 197–209; and E. M. Harwood and C. F. Brooks: Monthly Sequence of Sea-Surface Temperature on the New York-San Juan Steamship Route, *ibid.*, pp. 173–180.

[5] In this connection the term *Tropical air* need not always imply that only air of strictly tropical origin can be involved; for Polar air masses, after they have stagnated or passed for some time over warmer land or water far to the south of their source region, may act similarly to real Tropical air in causing fog when carried northward or over colder surfaces again. A more inclusive term would thus be "warm-air *advection fog*" (Willett), and this term and its opposite, "cold-air *advection fog*," are used in this paper.

There is a good deal of autumn, winter, and spring fogginess in the Oceanic regime, caused by *frontal* (mostly *prefrontal*) *fogs* as well as by *advection fogs* (*Tropical air*, *monsoon* (except in winter), *sea*, and some steam *fogs*). The cold-season *advection fog* tends to be somewhat greater where the summer *advection fog* is also greater; for the contrasts in water surface temperatures, both latitudinal and longitudinal, persist to a considerable extent throughout the year. As we approach higher latitudes, however, the incidence of *frontal* and warm-air *advection fogs* decreases in the very cold months owing to the extension of the Polar high, whereas it increases in the spring, summer, and autumn owing to the greater frequency then of cyclonic storms. Indeed, in the Arctic and sub-Arctic the summer maximum is probably considerably reënforced by *frontal fogs*.

Equatorward the air-water and water-water contrasts in temperature generally become too feeble for summer fog even before the trade-wind belt is reached. Winter fog (chiefly *frontal*) persists farther south than summer fog, however, owing to the corresponding shift of the winter storm tracks, with the result that a relatively narrow zone having a winter maximum is generally found between the practically fog-free tropic seas and the summer-maximum regime of the higher latitudes. Relatively cold waters or currents along the margins of the continents tend to carry their foggy belts abnormally far into lower latitudes, as illustrated along the coasts of California, Peru, the Iberian Peninsula and northwestern Africa, and southwestern Africa.

Poleward the summer maximum extends far into the pack-ice zone, if not to the very poles; for snow or ice surfaces, especially if melting, have much the same effect as cold, open waters. In winter there is a peculiar secondary maximum on the ice due to ice-crystal "mists" of radiational origin[6] and to steam mists (*Arctic sea smoke*) over leads of open water or thin ice.

The Continental Regimes

The conditions that give rise to fog are much more complex over a continent than over an ocean. The basic meteorological causes of fogs are practically the same, but they occur in characteristically different proportions and frequencies. The temperatures of the land and of its air masses are much less uniform than those of the sea in both time and space, and hence the occurrence of fog over a continent is less uniform. The great variety of surface conditions—topography, vege-

[6] These are not often very dense, however. They are described in many polar accounts. Similar "mists" may also be produced by advection. For a discussion of pack-ice fogginess see H. U. Sverdrup: Meteorology, Part 1, Discussion (Norwegian North Polar Expedition with the "Maud" 1918–1925, Sci. Results, Vol. 2), Geofysisk Institutt, Bergen, 1933, pp. 274–280. On the Greenland icecap these "mists" predominate, with an autumn (or winter?) maximum, as is true of a typical *radiation fog* regime of the land! See H. U. Sverdrup, Helge Petersen, and Fritz Loewe: Klima des Kanadischen Archipels und Grönlands (Handbuch der Klimatologie, edited by W. Köppen and R. Geiger, Vol. 2, Part K), Berlin, 1935, pp. 73 and 85–86).

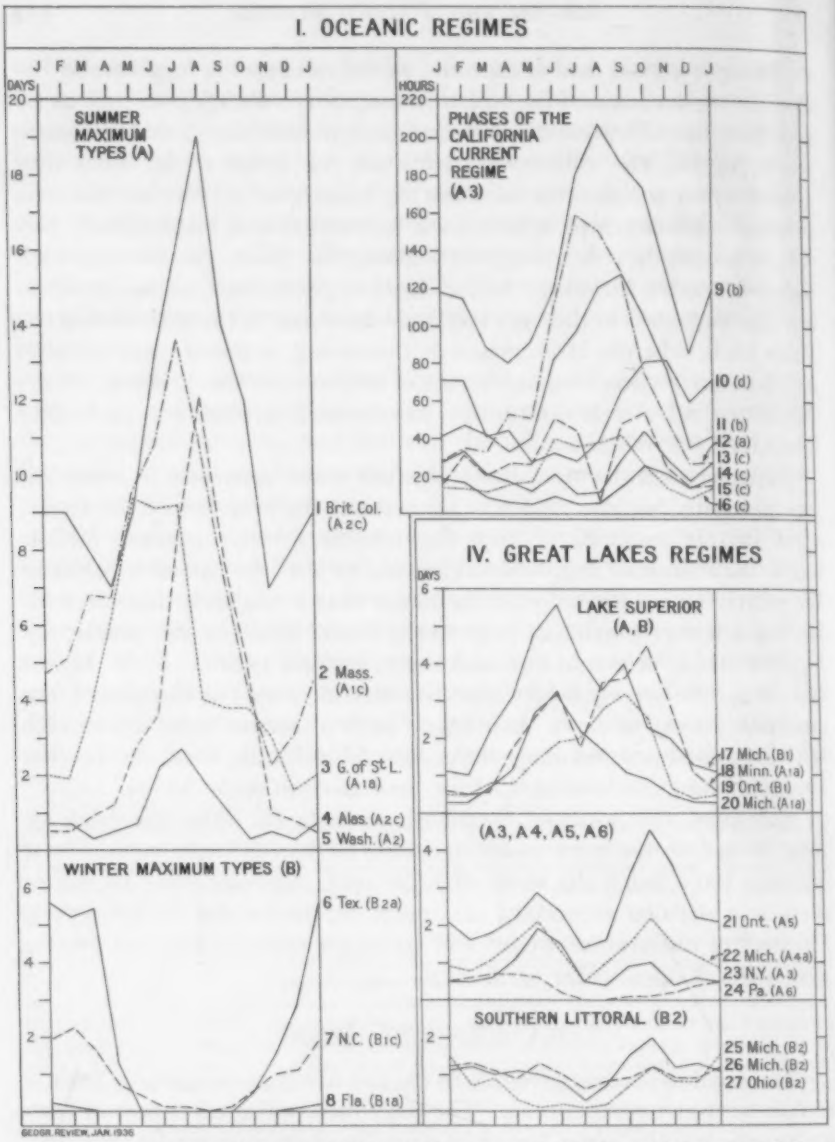

FIG. 2—Curves showing frequency of "dense fog" at some typical stations with Oceanic and Great Lakes fog regimes. The upper right-hand graph shows the mean number of hours during which fog signals were worked at certain lighthouses along the California coast and is based on records of 15 to 23 years (data from Hurd, Fog at Sea). The other graphs show the mean number of days with "dense fog" (records 20 years or more in most cases).

Key to stations: 1, Triangle Island; 2, Nantucket; 3, Bird Rocks; 4, Kodiak; 5, Tatoosh Island; 6, Galveston; 7, Hatteras; 8, Key West; 9, Blunts Reef; 10, Los Angeles, outer harbor; 11, Farallon Islands; 12, Pt. Arguello; 13, Pt. Loma; 14, Ballast Point; 15, Hueneme Point; 16, Pt. Conception; *17, Houghton; *18, Duluth; *19, Port Arthur; 20, Marquette; 21, Toronto; 22, Alpena; 23, Oswego; 24, Erie; *25, Port Huron; 26, Grand Haven; *27, Toledo. The code numbers and letters in parentheses refer to the classifications given in Appendix II. *References 17 and 27 should refer to the dotted lines, 18 and 25 to the nearest solid lines, and 19 to the broken line.

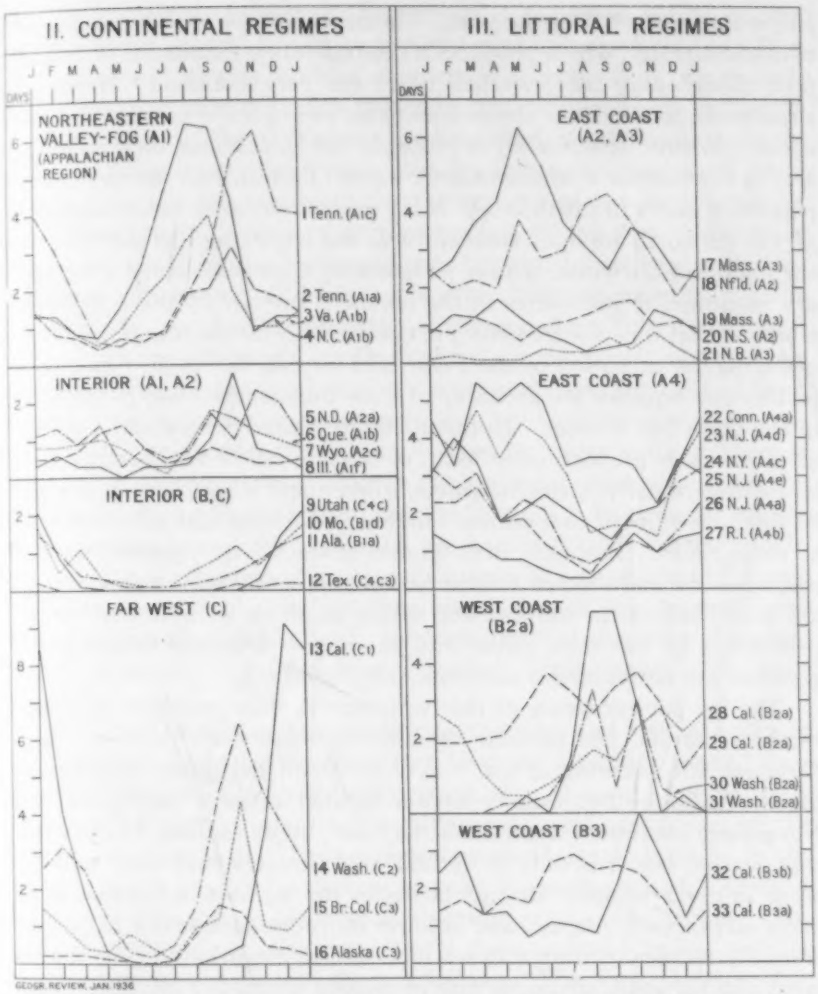

FIG. 3—Curves showing mean number of days with "dense fog" at stations with Continental and Littoral fog regimes.

Key to stations: 1, Chattanooga; 2, Knoxville; 3, Wytheville; 4, Asheville; *5, Ellendale; 6, Quebec; 7, Cheyenne; 8, La Salle; 9, Salt Lake City; 10, Springfield; 11, Montgomery; 12, El Paso; 13, Fresno; 14, Seattle; 15, Victoria; 16, Juneau; 17, Newburyport; 18, St. John's; 19, Boston; 20, Sydney; 21, Chatham; 22, New London; 23, Cape May; 24, New York; 25, Sandy Hook; *26, Atlantic City; 27, Providence; 28, San Francisco; 29, San Luis Obispo; 30, East Clallam; 31, Neah Bay; 32, San Diego; 33, Los Angeles. The code numbers and letters in parentheses refer to the classifications in Appendix II. *After 6 for b read e; after 26 for a read d.

tation, soil, and water bodies—and especially their relative abilities to gain or lose heat and moisture account for the complexity of continental fogginess.

Two important sets of climatic conditions favor a general tendency to winter fog. One is the production of *advection fog* in warm, moist air masses by their passage over colder surfaces, especially snow or

ice, in the winter half of the year. The other is the winter maximum of cyclonic activity, which produces a corresponding maximum of *frontal fogs*, though only the *prefrontal* types are very common. However, these conditions exist at this season to an even greater extent over the ocean. Winter *advection fog* is probably not so common on land as at sea; in the interior of the continent warm (Tropical) air masses rarely penetrate north of latitude 45° N. in midwinter, and hence *advection fogs* in the north are more frequent near the beginning and end than in the middle of the winter season. *Frontal fogs*, likewise, suffer a secondary minimum in midwinter in the northern interior of the continent, where at that time the frequency of cyclonic storms decreases poleward owing to the extension of the Polar cold-air cap or "high," and as a further consequence are probably of some importance even in summer in the Canadian interior. In the northern United States and Canada an appreciable proportion, at least, of the late-fall or early-winter and late-winter or early-spring fogginess, where there is any, may generally be safely attributed to a normal tendency to *frontal* and *advection fogs* at those times. The same may be said of the winter fogginess in the south-central and eastern United States and, as far as the *frontal fogs* are concerned, of the autumn and spring fogginess as well. In spring persistence of the snow cover and the steep poleward temperature gradient are favorable for *advection* and *frontal fog*.

The fog par excellence of the continent is that produced by nocturnal radiation, the familiar *radiation* (*ground* and "valley") *fog*. Although not unknown at sea, it is of local and negligible significance there. *Radiation fogs* usually have a decided autumn (September to November) maximum; sometimes they are almost entirely confined to that season, but it is only in certain arid climates that they cannot occur in every season. In high latitudes the autumn maximum normally advances to August, and in lower latitudes outside the tropics it normally recedes to winter at sea level or low elevations. The maximum also normally advances with increasing altitude.[7] Besides these isothermal variations of the autumn maximum there are tendencies in the northern parts to secondary, or occasionally even to primary, maxima in spring and in midwinter. Every *radiation* (*ground* or "valley") *fog* is necessarily associated with a radiationally produced ground inversion of temperature, but the fog maximum does not usually come when the inversions are most frequent or intense; rather it appears at the latter part of the season of highest absolute and relative humidity. In the Appalachian region, for example, the inversions are generally most frequent and intense in April or May and again in November or winter and are least frequent in summer. The fog maximum, however, is in September or October. At this time the

[7] This is well shown in the Appalachians and also in the Swiss Alps (Gottfried Streun: Die Nebelverhältnisse der Schweiz, *Annalen der Schweizerischen Meteorol. Centralanstalt, 1899*, App. No. 6, p. 11).

steadily increasing length of the nocturnal radiation period at the expense of the diurnal insolation period exerts a marked cooling effect on air that still retains much of its summer moisture and brings such high average relative humidity that only moderate cooling is needed to produce fog.[8] In the northeast, the humidifying and cooling effects of late-melting snow cover, saturated ground, and rains make some spring *radiation fog* possible. On the interior plains in summer it sometimes occurs directly after showers late in the day. Moist air from oceans or lakes is often fogged over the near-by land by nocturnal radiation. In winter *radiation fog* is ordinarily prevented to a great extent by the low absolute humidity of the prevalent Polar-continental air. Excessive radiational cooling over the snow cover, however, or the humidification of air masses from stagnation over the land or from passage over water favors a few *radiation fogs* that may cause or contribute to a midwinter maximum or secondary maximum if there is little fog in other seasons. Thus in the arid intermountain region the air is so dry that only the coldest months have fog. In elevated valleys of the western mountain region, on the northern High Plains, and in the interior of Alaska and northern Canada as well as on the Arctic ice fields winter *radiation fogs* often occur at such low temperatures that they consist of ice crystals;[9] in some parts of the West these are called "pogonip,"[10] in the Arctic "mist," "frost haze," or "frost smoke."

A type of *radiation fog* peculiar to the east and west margins of the continent is called *maritime fog* because, although formed over land, it develops in fresh Polar-maritime air. It occurs frequently in autumn and early winter in the valleys and enclosed basins of the Pacific slope but is much less common on the Atlantic slope.[11] In the interior basins west of the Sierras and the Montana–British Columbia Rockies *maritime fog* is often associated with stratus-like *high fog*. The Polar-maritime air readily stagnates in these enclosed basins, and the usual subsidence of dry air above it follows. This forms a descending free-air inversion. Radiation from the top of this inversion soon condenses the accumulating moisture beneath into a stratus that, although it almost always sets in after the *maritime fog* has begun below, builds down to meet the *maritime fog* building up and prevents its early dissipation: the result is an extremely persistent kind of fog,[12]

[8] H. J. Cox: Thermal Belts and Fruit Growing in North Carolina, *Monthly Weather Rev. Suppl. No. 19*, 1923, pp. 55–91, especially Figs. 52, 53, and 76.

[9] H. C. Willett: American Air Mass Properties, *Papers in Physical Oceanogr. and Meteorol., Mass. Inst. of Technology and Woods Hole Oceanogr. Instn.*, Vol. 2, No. 2, 1933, pp. 14–15.

[10] Ward, The Climates of the United States, p. 307; J. C. Alter: Pogonip (unpublished manuscript).

[11] Willett, Synoptic Studies in Fog, pp. 13–15.

[12] See W. M. Lockhart: A Winter Fog in the Interior, *in* Characteristic Weather Phenomena of California, by H. R. Byers, *Meteorol. Papers, Mass. Inst. of Technology*, Vol. 1, No. 2, 1931, pp. 11–20; R. C. Counts, Jr.: Winter Fogs in the Great Valley of California, *Monthly Weather Rev.*, Vol. 62, 1934, pp. 407–410; and A. B. Carpenter: Subsidence in Maritime Air over the Columbia and Snake River Basins and Associated Weather (Abstract), *Bull. Amer. Meteorol. Soc.*, Vol. 16, 1935, p. 224.

which sometimes lasts for many days. *High fog* may also occur without *maritime fog*; occasionally it even reaches the valley bottoms, but generally it only fogs the intermediate slopes of the mountains. In the dry-summer basins the onset of *maritime fog* seems to require a wet ground, and hence the foggy season begins after the first rains.[13]

The relation of *radiation fog* to topography has an important bearing on its frequency and distribution. Over flat plains or wide lowlands in spots where the radiationally cooled air is prevented from gravitating away, and especially over damp or swampy ground such as the coastal-plain marshes and California tule bottoms, shallow *radiation fogs* (true *ground fogs*) are apt to be frequent, though they enter into the statistics at only a few stations. In well marked depressions and valleys the *radiation fogs* (true "valley fogs") are denser, deeper, and more frequent in proportion as the valleys are deeper, more elevated, narrower, and more enclosed, other factors being equal. This is particularly noticeable in the eastern United States, where "valley fogs" predominate. However, in regions with *radiation fog* maxima in most of the valleys the uplands and those valleys that have good air drainage to lower levels will probably experience the winter-maximum regime of *frontal*, orographic (see below), and *advection fogs*, and higher elevations that reach into the lower cloud levels will have still different regimes dependent largely on the cloud frequency (see Table I, p. 126).

Rivers and inland lakes tend to create their own regimes. In late summer and autumn the relatively warm surface waters of small or shallow lakes and rivers, if located in well defined depressions, may give rise to frequent nocturnal *steam mists*. Sometimes these are enough to cause a definite autumn-maximum or autumn secondary-maximum regime over the water and adjacent shores where such a regime would not otherwise be found. Usually, however, they only reënforce the existing regional "valley fog" maximum, since both "valley fogs" and *steam mists* are favored by the same topographic and climatic conditions. The waters of large, deep lakes and turbulent rivers are apt to be too cool in autumn for *steam mists*. During severe cold spells of winter unfrozen areas of rivers and lakes generally "smoke" or "steam" (*Arctic sea smoke*); in spring the relatively cold waters of large rivers and lakes may produce more or less fog akin to *monsoon* or *Tropical air fog* (see Great Lakes regimes, below).

Another important type of land fog, not generally recognized by itself, may be called orographic fog. This is the result of the adiabatic cooling of the air by forced ascent up the slopes of plains, plateaus, hills, or mountains. On abrupt mountain masses it is more properly called "cloud," since most of it in that case forms in the free air; but when it forms mostly in contact with the ground over a large

[13] Counts, *op. cit.*

area, as happens sometimes with ascent of moist air up the long slopes of the Piedmont and the western plains, the term "fog" seems correct. Such orographic effect is, however, often combined with *radiational*, *advectional*, and *frontal* effects in producing fog. Nevertheless, the orographic factor is important in the spring fogginess of the High Plains and in the winter fogginess of the upper Piedmont, the Appalachian region, and indeed all mountains or elevated plateaus.

In general the great difficulty in explaining continental regimes is to estimate the relative proportion of *radiation*, *advection*, *frontal*, and orographic fogs in each season or month.

The Littoral Regimes

The littoral regime is a transitional type between an oceanic (or lacustrine) regime and a continental regime. In our scheme it is practically limited to land areas over which there is enough drifting of *advection fogs* formed over sea or lake (*monsoon*, *Tropical air*, steam, and *sea* fogs only) noticeably to affect the regime.[14]

As the littoral regimes are merely transitions, they show no great homogeneity within the types nor very extensive areal distribution except in narrow belts roughly parallel to the coasts; and even these belts may be discontinuous, for in many coastal regions either no transition at all appears or else it takes place in so short a distance that our net of stations misses it completely.

Irregular coastal topography adds great complexity to the distribution of littoral fog. Coastal mountain ranges hasten the transitions and inject special altitudinal and orographic influences. On hills and mountains along foggy coasts there is generally some zone along the middle or higher seaward slopes that has the regime of the neighboring water area in almost unaffected form as a result of the onshore drift of the fogs. The shore itself and the lower elevations may have an oceanic, a littoral, or a continental regime according to the extent to which the warmth of the ground or of the shore waters can dissipate the lower parts of sea fogs as they come inland. Frequently, when a sea fog is dissipated over the warmer coastal lowlands, nocturnal radiation or forced ascent over hills locally refogs the humid sea air.

The usual wind direction during fog over the coastal waters is

[14] The drifting of a land fog of any kind over the water is, compared with the reverse phenomenon, negligibly rare. *Frontal* and warm-air *advection fogs* formed on land are sometimes carried from the east and north coasts of the continent over the water, but probably not very far as dense fog unless the water is frozen. In this case the ice acts as a land surface, so that a true littoral situation cannot then be said to exist. Along parts of the California coast and probably elsewhere, shallow *radiation fogs* formed over the land sometimes drift a short distance on the water.

That the littoral regime, as here defined, belongs chiefly to the land may also be inferred from the facts that the water is generally warmer than the land at the seasons when the land is foggiest and that air masses chilled and fogged over a cold ocean, because of the greater uniformity of oceanic conditions, are generally chilled to a greater depth and are therefore likely to continue over a warmer surface (land or water as the case may be) for a longer time than air masses chilled and fogged over cold land.

obviously a basic factor in the littoral regimes. The diurnal type of sea breeze has been much overrated as an importer of fog to the land. On east coasts of land areas the cyclonic (prefrontal) easterly indraft ("sea turn") or the return flow of air in the rear of weak, stagnant anticyclones and cyclones is certainly a controlling influence in the littoral regimes. Even pre-thunderstorm indrafts are of importance. On west coasts the prevalent westerly winds assure pronounced littoral fog. Bays, estuaries, rivers, valleys, etc. may or may not carry the influence of a water regime farther inland, but they often create local and peculiar varieties of both the littoral and the water regimes, according to the size of the inlet and the peculiarities of its water surface temperature and winds. An ocean or lake regime may extend some distance onshore in its pure form; commonly it envelops at least the more exposed promontories. Thus the littoral regime often begins somewhat inland rather than at the water's edge.

Other things being equal, coasts with prevailing onshore winds and pronounced contrasts between sea and land temperatures experience the most marked development of littoral regimes as well as the greatest onshore reach of the water regimes.

The Great Lakes Regimes

The individual regimes of the Great Lakes and their shore lines are essentially like those of the ocean and its coasts. The Great Lakes as a whole, therefore, present something of an epitome of the fog distribution of an ocean.

The clue to the details of these regimes lies in the comparison of the water temperatures with the air temperatures of the surrounding land.[15] From March or April to September or October the water is, on the average, colder than the air, and therefore conditions are favorable for warm-air *advection* (largely *monsoon*) *fog* over the water; during the rest of the year the air is, on the average, colder than the water, a condition favorable for cold-air *advection* (steam) *fog* over the water before it freezes.

Like an ocean, therefore, the Great Lakes as a whole tend to more fog in the warmer season; also, as on the ocean, the greatest fogginess occurs when and where the waters are coldest in relation to the surrounding land or water. Owing, however, to the small size of the lakes

[15] For air and water temperature data see "Final Report . . . , Waterway from Lockport, Ill., . . . to the Mouth of the Illinois River," *63rd Congr., 2nd Sess., House of Repr. Doc. No. 762*, 1914, pp. 42–71 and Pl. C; Chester Dewey: Temperature of Lake Ontario, *Amer. Journ. of Sci.*, Ser. 1, Vol. 33, 1838, pp. 403–405; the same: On the Temperature of Lake Ontario, *ibid.*, Vol. 37, 1839, pp. 242–243; W. F. Cooper: The Variation of Land and Water Temperatures, *7th Rept. Michigan Acad. of Sci.*, Lansing, 1905, pp. 40–43; R. E. Horton, in collaboration with C. E. Grunsky: Hydrology of the Great Lakes: Report of the Engineering Board of Review of the Sanitary District of Chicago on the Lake Lowering Controversy and a Program of Remedial Measures, Part 3, App. 2, 1927, Ch. 8; and J. R. Freeman: Regulation of Elevation and Discharge of the Great Lakes, revised to October 1, 1926, pp. 116–128 and 475–477. Horton excellently summarizes all available surface and air temperature data.

as compared with an ocean, real *sea fog* is practically absent, and therefore the tendency to a fog maximum in midsummer, when the contrasts in water temperatures are greatest,[16] is also lacking. The Great Lakes regime is due rather to *monsoon fog*, whose maximum here comes in spring, when the land-water temperature contrast is greatest owing to the more rapid warming of the land. On Lake Superior, north-central Lake Michigan, and northwestern Lake Huron the maximum occurs in late May and June; elsewhere in late April and May.

In general, as the lake temperatures become colder from south to north and from the shores outward, fogginess increases northward and toward the central parts of each lake (see Fig. 1). There are, however, two notable exceptions to the lakeward increase: on Lake Huron the foggiest belt touches the northwest shore where cold water upwells, and it is reported that on Lake Ontario the fog is as frequent over the shore waters as in the middle, for reasons unascertained.

On all the Great Lakes, although less noticeably so on Lake Superior, there is also a tendency to autumn (September-October) fog, amounting in some places to a secondary maximum or even to the chief maximum. This is largely *monsoon fog* of a type that is peculiar in that it seems to be associated with *frontal fog* to an unusual extent. Hence it is impracticable to distinguish clearly *frontal fogs* from *advection fogs* over the water at this season. The same thing happens in spring and summer too, but much less frequently.[17] In summer and autumn (August to October) the average dew-point temperature of the air is much lower than the average lake temperature, whereas in spring the dew point is but little below the water temperature[18] or may actually be above it, as on Lake Superior. Consequently in spring the *monsoon fog* forms with a great variety of wind directions and air masses, whereas in autumn it generally forms only in the more humid air before the warm or cold fronts. The autumn fogs are thus much likelier to form with easterly and southerly than with westerly winds. In spring, however, a westerly wind is almost as likely to produce fog as other winds, and, being a frequent wind, it causes the actual amount of fogginess on the windward (east) sides of all the lakes except Superior to be considerably greater in spring than in autumn, when it is not so likely to make fog. The windward sides have much autumn fog also, because in autumn, as in spring, moist, warm southwesterly winds are rather readily fogged (*monsoon* and *Tropical air fog*) by the

[16] Marked general as well as sharp local contrasts in surface temperatures do exist (Horton, *op. cit.*; Freeman, *op. cit.*, pp. 475–477), but for the most part the air passing over them is of such recent land origin that any fog that results should probably nearly always be called *monsoon fog* rather than *sea fog*.

[17] A more or less minor part of the spring and autumn fogginess is of course due to general *frontal* and *advection fogs* formed over both land and lake.

[18] Diagrams for each lake illustrating the curves of dew-point and water temperature through the year are very instructive (see those in Freeman, *op. cit.*, p. 128).

time they reach the north or east sides. The leeward (west) sides of the lakes (again excepting Superior), on the other hand, have about as much autumn as spring fog, if not a little more, because a larger part of the spring fog comes with the rather frequent westerly winds, whereas the autumn fog tends to come oftener with easterly winds.

It is evident, then, that the leeward and windward sides and shores of the Great Lakes have more or less contrasted regimes as far as the spring and autumn fogginess is concerned. Over the middle parts of the lakes there is more spring than autumn fog. Autumn fog may or may not appear as a secondary maximum and in proportion to spring fog decreases northward over the colder waters.

There is much less fog over the lakes in winter and summer than in spring or autumn. The northern parts are generally frozen in winter, and except for an occasional "steaming" the fog that occurs must be chiefly due to conditions prevailing over the land as a whole; the southern lakes are not much frozen, but, being usually warmer than the air, they cause little dense fog. The south ends of Lakes Michigan, Huron, and Erie reach into the part of the continent where there is considerable midwinter fog or even a winter maximum, and this fog is not altogether lacking over the warm waters. In general the regime over the lakes has its chief minimum in winter, but to the south, especially near the shores, the waters become so warm that the minimum there generally comes in summer.

The littoral effect of the Great Lakes is slight as compared with that of the ocean because the lakes are so small in relation to the land about them that their thermal effect is quickly dissipated inland. The greater warmth of the shore waters also tends to keep the fogs from reaching the land; the wind carries the warmer surface water to the side of the lake toward which it blows, and the chances of fog near the shore and on the shore are thus reduced. The littoral regimes, therefore, comprise but narrow belts; even on windward shores the fogs rarely drift much more than five or ten miles inland, and south of the Mackinac district they commonly stop practically at the shore. The colder and foggier the shore waters, the farther inland the littoral regime is likely to extend. Around Lake Superior topography probably forbids a greater extent of the littoral regime. Most of the region about the Great Lakes has an autumn *radiation fog* maximum, and therefore about as fast as the autumn lake fogginess decreases inland it is replaced by increasing *radiation fog*.

Appendix I—Note on the Data and Maps

The United States Weather Bureau has from its beginning annually summarized and published[19] "the number of days with dense fog" at its first-order stations for each month and the year. Mean values for the full period of record of each station

[19] *Reports of the Chief of the Weather Bureau*, 1891–1892 to date.

(through 1931 or 1932) were computed by the present writer where not already available in print[20] or from Weather Bureau officials. Data were obtained for 410 stations in all,[21] including many non-Weather Bureau observatories and about 100 stations outside the United States proper, but the means cover diverse periods of many different lengths.

The data are unsatisfactory to a certain extent because (1) they are limited to "dense fog" and to "days with fog";[22] (2) observing hours did not always cover the entire day; (3) the topographic situations of the stations are not representative enough, and some of the sites or local conditions have changed from time to time; (4) there are not enough stations; and (5) many of the records are too short. However, the longer-period means lead to such consistent geographical expression that the greater part of the first three defects must affect all stations in all months similarly. Only in the United States are there enough stations for detailed geographical treatment and data homogeneous enough for detailed analysis.

The "number of days with dense fog" fails to an undetermined but not inconsiderable extent to represent the true fog frequency. This affects the intercomparability of the numerical values for different stations much more than it does that of the values for different months or years at any one station. Consequently the data may be interpreted much more literally in considering the annual regimes than in studying the geographical variations. Nevertheless, the data from station to station as plotted on the mean annual frequency map (Fig. 1) seem so consistent that a remarkably smooth and logical pattern results. Much of the detail, however, is frankly speculative, yet the scale of the map does not permit the representation of some interesting, definitely known details. Caution must be observed against inferring the frequency of fog over large lakes and the oceans, even a mile offshore, from frequencies indicated at shore and near-shore stations, for land fogginess and water fogginess are generally radically different. The positions of the isopleths extended over the water bodies[23] and into Canada and Mexico are quite hypothetical, though their general pattern is in accord with known facts or data. In view of the deficiencies in the data, the values assigned to the isopleths must everywhere be regarded as more of relative than of absolute significance.

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[20] The nucleus of the mass of data used was obtained from the tables of means for 108 United States (30-year means, uniform period, reduced to 30.44-day months) and 26 Mexican stations in the forthcoming volume by R. DeC. Ward, C. F. Brooks, and A. J. Connor on the climatology of North America constituting Handbuch der Klimatologie, Vol. 2, Part J, Berlin, 1936, pp. 64 and 246–248. The remainder of the published data were found in a large number of scattered sources in journals and books.

[21] In addition, data were obtained from about 500 lighthouses, 62 of which give monthly values.

[22] In the United States the Weather Bureau distinguishes arbitrarily between "light" and "dense" fog. A dense fog obscures objects at 1000 feet or less, a light fog at more than 1000 feet. No upper limit of visibility is indicated between light fog and haze or no fog. Elsewhere various other criteria have been used, and the fog data of the United States are not strictly comparable with those of Canada and Mexico. The data for light fogs include so many cases of smoke, haze, dust, and falling precipitation that they could not be used in this study. The ratio of light fog to dense fog apparently averages about 3 : 1 but ranges in individual cases from 0.1 : 1 to 20 : 1.

[23] Charts of normal fog frequency on the Great Lakes appear in A. J. Henry and N. B. Conger: Meteorological Chart of the Great Lakes, 1901, No. 2, Summary for the Season of 1901, U. S. Weather Bureau, Washington, 1902. A number of charts and tables showing on rather small scales the normal monthly fog frequencies at sea have been published: the monthly *Pilot Charts* of the North Atlantic Ocean and of the North Pacific Ocean published by the U. S. Hydrographic Office; *Monthly Weather Rev.*, Vols. 14–23, 1886–1895; Pls. 13–24 accompanying Gerhard Schott: Die Nebel der Neufundland-Bänke, *Annalen der Hydrogr. und Marit. Meteorol.*, Vol. 25, 1897, pp. 390–393, reprinted in "Atlantischer Ozean: Ein Atlas," 2nd edit., Deutsche Seewarte, Hamburg, 1902; "Oceanographische en meteorologische waarnemingen in den Atlantischen Oceaan," *Kon. Nederl. Meteorol. Inst. Publ. No. 110*, in 4 parts, De Bilt, 1930; monthly charts of "Fog and Mist over the North Atlantic 30°–60° N.," *Marine Observer*, Vol. 4, 1927; and W. E. Hurd: Fog at Sea, published on the back of various *Pilot Charts* of the U. S. Hydrographic Office since 1927. The average number of hours that the fog signals at each lighthouse in the United States have operated may be obtained from the U. S. Bureau of Lighthouses (blueprinted).

TABLE I—LOCAL ALTITUDINAL CONTRASTS IN FOGGINESS

(Mean number of days with dense fog)

STATION ELEVATION (FEET)	LENGTH OF RECORD (YEARS)	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	YEAR
Mt Weather, Va.														
1725	20	9.0	6.4	9.0	7.9	8.6	7.4	5.0	10.0	9.6	8.2	5.6	8.5	95.2
Elkins, W. Va. (valley)														
1950	32	1	1	2	1	3	6	9	11	13	10	4	1	62
Washington, D. C.														
110	59.8	1.8	0.9	0.9	0.5	0.3	0.3	0.1	0.3	0.8	1.7	1.8	1.5	10.9
Mt. Washington, N. H.														
6284	1 (1933)	24	27	29	25	23	26	28	30	24	27	26	29	318
Pinkham Notch, N. H.														
2000	1 (1933)	0	0	0	9	4	1	4	2	4	1	0	3	28
Cincinnati: Abbe Obs.														
670	1 (1932)	4	4	0	0	0	2	1	0	2	1	3	3	20
Cincinnati: Airport														
500	1 (1932)	3	3	2	2	2	7	4	1	2	6	3	3	38
Pikes Peak														
14,140	1.8	10.5	11.5	13.5	9.0	10.0	6.0	10.5	15.5	5.0	3.0	11.0	13.0	118.5
Colorado Springs														
6072	1.8	0.5	0.0	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.0	0.0	1.0	4.0
Denver														
5292	30	0.6	0.3	0.7	0.3	0.3	0.1	0.1	0.3	0.2	0.4	0.5	0.5	4.4
Mt. Hamilton, Cal.														
4210	5	0.8	1.8	2.4	3.4	1.8	1.0	0.4	0.2	1.8	1.2	1.0	1.2	17.0
San Jose, Cal.														
141	26	3.6	2.5	2.0	0.5	0.2	0.5	0.9	2.0	2.0	2.9	3.0	4.1	24.0
Mt. Tamalpais (top), Cal.														
2375	22.2	15.6	13.5	12.6	9.6	9.0	5.1	2.7	3.6	6.0	7.1	11.0	13.4	109.2
Mt. Tamalpais (west slope)														
700?–2300	6	4.5	5.2	9.7	12.2	18.2	23.2	27.8	27.2	18.7	13.8	10.2	7.3	178
Pt. Reyes, Cal.														
650	15?	8	8	7	7	9	12	20	21	15	13	10	7	137
San Francisco														
150	40	2.7	2.3	1.1	0.5	0.5	0.8	1.2	1.7	1.4	2.3	2.8	2.2	19.4
Greenland icecap[a]														
8200	0.5	24	18	7	...	...	...	...	...	11	14	21	21	(116)
Greenland fiord (base)														
51	1	1	3	0	0	11	4	5	1	2	1	0	2	30
Blue Hill, Mass.[b]														
635	10	8.2	6.2	8.6	10.3	8.4	8.8	4.8	4.8	7.7	5.0	6.5	5.2	7.0
Neponset Valley, Mass.														
50–500	10	0.6	0.2	0.3	0.2	0.5	1.4	2.0	2.9	4.8	5.5	2.1	0.9	21.4

[a] No observations made on Greenland icecap April-August, but probably there is a midsummer secondary maximum. Data from the British Arctic Air-Route Expedition, 1930–1931.

[b] The Blue Hill data are given in per cent of time foggy (7 a. m.–7 p. m.).

Taken as a whole, the map cannot be regarded as showing much more than the general distribution of fog in the valleys, where most of the stations happen to be. In the few localities where data permit comparison of valley fogginess with that of near-by slopes, uplands, or mountain tops, striking differences in amount and seasonal distribution appear; in mountainous country the fog regime above a certain level is in reality largely a cloudiness regime and in the absence of actual observations may be

inferred approximately from a knowledge of the frequency of clouds of the appropriate level and kind over the general region. Table I presents data for some valley-upland comparisons.

The urban situation of most of the stations suggests that smoke and city heat may have some systematic effect on the statistics. The net effect of smoke is probably negligible,[24] but the artificial heat of the city and its modified terrain seem to cut down considerably the frequency[25] and duration of "dense" fogs, especially the shallow *radiation* types.

In regard to mapping fog regime distributions, it must be explained that in most of Canada, Alaska, and Mexico the data are insufficient to identify and delimit the types in detail, if at all. Some of the types found in the United States apparently extend far beyond its boundaries, and a number of types peculiar to Canada, Mexico, and Alaska are tentatively identified or surmised, as indicated in the text but not on the map. The classification and delimitation of the subtypes over the coastal waters and at sea are rather speculative, since they are based on the records at outer shore and island stations for the most part, and the rather crude records from ships do not afford a convincing check on the seaward extent of the coastal varieties.

The transitions between types are generally much more gradual than suggested by the boundary lines on the map, though along the coasts and in the mountains they may actually be abrupt. The lines are placed where presumably the maxima of each adjacent type combine in equal amplitude. Where the transition takes place so gradually that a number of stations scattered over a considerable area show it, a transitional regime type may be recognized; indeed, a number of such were differentiated, and of course with a fine-mesh net of stations it would have been possible to identify an almost infinite number of transitional types.

Appendix II—Synopsis of Fog Regimes

In the following synopsis the serial numbers in square brackets correspond to the numbers on the map, Figure 4. Many of the types listed are illustrated in Figures 2 and 3.

I. Oceanic Regimes

A. Summer-maximum types.

1. Northwestern Atlantic regime [1]: Near the coast maximum sometimes in June; generally in July, rarely in August; for some distance north and east of Newfoundland, in June; midwinter minimum if there are no complications.[26]
   Subtypes: (*a*) With spring secondary maximum: due to icy coastal currents,[27] ice fields, floes, or bergs,[28] or some increase or weakening in

[24] Any tendency to increased dense fog due to the hygroscopic nature of smoke is offset by the opposite tendency due to the checking of radiational cooling by smoke clouds. The marked local increase in frequency, duration, and density of fog due to increasing smokiness that was formerly observed over a span of many years in the great cities of Europe is unnoticeable in America, if it has occurred at all, probably because it is chiefly an accompaniment of *maritime* and *high fogs*, which are of limited occurrence here.

[25] In New York City there are 13 more days of dense fog a year at the Battery (water's edge) than at Central Park in the center of Manhattan, though the regime is the same; the Jersey meadows across the river (Newark Airport) have about 22 more days than the Battery.

[26] See the monthly *Pilot Charts of the North Atlantic Ocean* of the U. S. Hydrographic Office.

[27] Bigelow, Physical Oceanography of the Gulf of Maine, pp. 543–596 and 824–854.

[28] Ice fields and floes, and also to some extent icebergs, delay the vernal warming of the water and may themselves be swathed in fog. The persistence of ice fields in the Gulf of St. Lawrence well into spring is certainly the cause of the abnormal amount of spring fog in that region. For the state of the ice, water temperatures, and weather about Newfoundland and the Grand Banks see "International Ice Observation and Ice Patrol Service in the North Atlantic Ocean," *U. S. Coast Guard Bulletins*, 1913 to date; and for the Greenland region see "The State of the Ice in the Arctic Seas: Summary, Average Limits etc." and "Monthly Mean Temperatures of the Surface Water in the Atlantic, North of 50° N. Lat." (respectively Special Print and Appendix of the *Nautical Meteorol. Ann.*), Danske Meteorol. Institut, Copenhagen, 1917. See also Schott, *op. cit.*

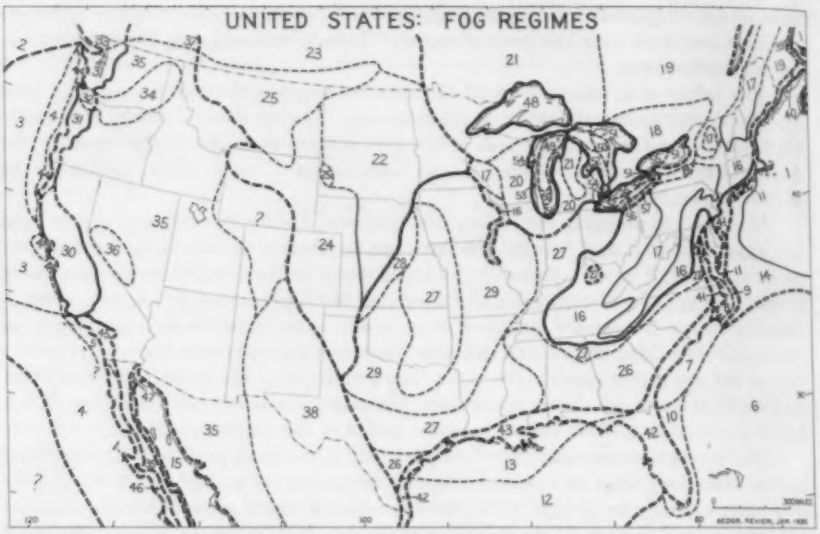

FIG. 4—Map showing areas of different fog regimes in the United States. The numerals correspond to the figures in square brackets in the text, pp. 127–134. The thicker lines represent the boundaries between the major distinctive types (or groups of types); the thinner ones separate minor types, subtypes, and phases. This distinction between major and minor follows the grouping given in the text for the most part. Broken lines are used either where the transition is very diffuse or where the data do not permit more than a rough guess as to where a line should go. The solid lines are the more abrupt or more definitely known boundaries. The broken and solid lines, however, are more subjective —the author's opinion concerning the probable position of the line. Several large areas whose regimes are very much in doubt are identified by a query (?).

cyclonic activity (more favorable wind system) (?); (*b*) With autumn secondary maximum: due to both *frontal* and *advection fogs;* (*c*) With midwinter or late-winter secondary maximum: in the Arctic; in middle latitudes due to increased *frontal* and *advection fogs.*

2. North Pacific regime [2]: July or August maximum; minimum in January or December if there are no complications.[29]

   Subtypes: (*a*) With spring secondary maximum: in Asiatic and north-central Pacific waters; (*b*) With autumn secondary maximum: off the coast of British Columbia and southeastern Alaska; due to upwelling of cold water; (*c*) With midwinter secondary maximum: generally in January, but in February off the United States coast (see California Current regime, below); northeastern Pacific region.

3. California Current regime: Over relatively cold upwelling along the coast from Cape Flattery to offing of Cape San Lucas.[30]

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[29] See the monthly *Pilot Charts of the North Pacific Ocean* of the U. S. Hydrographic Office.

[30] Although a good deal has been written about these regimes, many misconceptions concerning them have developed and still persist. Recently several excellent studies along modern lines have appeared, and these should be consulted for a fuller description and understanding: see H. R. Byers: Summer Sea Fogs of the Central California Coast, *Univ. of California Publs. in Geogr.*, Vol. 3, 1928–1930, pp. 291–338, and a revised briefer treatment by him in "Characteristic Weather Phenomena of California" (see footnote 12); and J. B. Anderson: Observations from Airplanes of Cloud and Fog Conditions along the Southern California Coast, *Monthly Weather Rev.*, Vol. 59, 1931, pp. 264–270. For surface-water temperature conditions see H. Thorade: Über die Kalifornische Meeresströmung, *Annalen der Hydrogr. und Marit. Meteorol.*, Vol. 37, 1909, pp. 17–34 and 63–76 and accompanying plates; and G. F. McEwen: The Distribution of Ocean Temperatures along the West Coast of North America, *Internatl. Rev. der gesamten Hydrobiol. und Hydrogr.*, Vol. 5, 1912, pp. 243–286. For monthly lighthouse data see Hurd, *op. cit.;* and A. H. Palmer: Fog along the California Coast, *Monthly Weather Rev.*, Vol. 45, 1917, pp. 496–499.

Phases: A February secondary maximum is noticeable in all phases, February being the time of lowest wind velocity and also of a secondary increase in the negative anomaly of the surface temperature of coastal waters: (*a*) [3] July-August maximum (normal phase?); (*b*) [4] August-September maximum, with sometimes a tertiary in June or July: north of the Golden Gate this is due to the later date of lowest water temperature; off the Golden Gate it is due to the effect of high midsummer wind velocity in lifting many of the fogs to stratus; and farther south, to the necessary passage of prevailing northwest winds from colder to somewhat warmer waters (?); (*c*) [5] September-October maximum (occasionally November near shore, Phase d), with a June tertiary maximum: coastal waters below Point Arguello tend in general to be relatively warm in summer, the water being colder than the air only in autumn,[31] which may explain the regime; the summer maximum fails to develop here, probably because in summer the prevailing northwest winds arrive from colder waters to the north and west dissipating fog at the surface; (*d*) October-November maximum (see Phase c).

4. Hudson Bay regime: July-August maximum, with probably a small midwinter secondary maximum of radiation (ice) "mists."
5. Arctic Pack-Ice regime:[32] July-August maximum, January secondary maximum, March tertiary maximum; April and October minima; however, if winter "mists" are not included in the statistics, there is no midwinter fog.

B. Winter-maximum types.

1. Western Atlantic winter regime.

   Probable phases: (*a*) [6] January (or December) maximum (over Gulf Stream and Central Atlantic?); (*b*) [7] January (or December) maximum, with March (or February) secondary maximum (influence of Phase c or Phase d); (*c*) [8] February maximum (Hatteras regime): February is the time of coldest coastal water here, which with the Gulf Stream near by to the east is favorable to fog with any easterly wind (*Tropical air fog* or *sea fog*); (*d*) [9] March maximum: coastal waters west of the Gulf Stream; similar cause to that of Phase c or else due to more frequent southerly and easterly winds (more *advection fog*) or frontal activity at this time (?); (*e*) [10] March or February maximum, January or December secondary maximum (influence of Phase a); subtypes of phases a to d: [11] With April-June secondary or tertiary maximum.

2. Gulf of Mexico regime [12]: January maximum, with no summer fog; steam fog with winter cold waves ("northers") off the land contributes to this regime;[33] *Tropical air fogs* are common in the northern Gulf, where winter waters are coldest.

   Subtype: (*a*) [13] With March secondary maximum: due locally to the effect of cold *débits* of rivers in chilling coastal waters and generally to the increase in frequency of onshore winds.

C. Spring-maximum types (transitions between winter and summer types).

1. Middle Atlantic transition regime [14]: April-June maximum, generally with winter and autumn secondary maxima; maximum comes at the time

[31] See Figure 1 in Burt Richardson: Solar Radiation at the Scripps Institution, La Jolla, Calif., 1928–34, *Monthly Weather Rev.*, Vol. 63, 1935, pp. 92–93. The Scripps Institution of Oceanography, La Jolla, Cal., has published surface temperature data for these waters in mimeographed tables and in *Univ. of California Publs. in Zoölogy*, Vol. 15, 1915–1916, pp. 255–356.

[32] Sverdrup, *op. cit.*, pp. 274–280.

[33] Hurd, *op. cit.*; *idem:* Northers of Mexican and Central American Waters, published on the back of various editions of the monthly *Pilot Charts* of the North Atlantic Ocean and of the Central American waters since 1930, U. S. Hydrographic Office.

when the water is coldest relative to the air. (The Pacific counterpart of this type appears along the Chinese coast.)

2. Gulf of California regime [15]: Midwinter secondary maximum (?); the water is probably coldest relative to the air in spring; extends south to offing of Cape Corrientes.

D. Autumn-maximum types: see Phases b, c, and d of California Current regime, above.

II. Continental Regimes

A. Types whose maxima are due largely or almost entirely to *radiation* (*ground* and "valley") *fogs*.

1. Northeastern valley-fog regime: Autumn maxima and summer or late-spring minima, sometimes secondary or tertiary maxima in winter due either to increase in *radiation fog* or to *frontal* and *advection fogs* (or both). Phases: (*a*) [16] October maximum; (*b*) [17] September (occasionally August) maximum; (*c*) November maximum: at Chattanooga, due to effect of unusually low elevation and low latitude for this type of regime; (*d*) [18] October maximum, spring secondary maximum (generally April); (*e*) [19] September maximum, spring secondary maximum (generally April or May); (*f*) [20] October maximum, February secondary maximum (see also Montana regime and North-Central Plains regimes, below); (*g*) [21] September maximum, February secondary maximum.

2. North-Central Plains regimes: These are the most difficult regimes of the continent to identify and explain. The total annual fogginess is small and is so well distributed through the year that no one month has very much more than another, many of the differences being within the errors of the statistics. The curves are generally irregular, having several secondary maxima and minima, and except where these are recurrent over some considerable area one cannot be sure of their reality. There is no use in distinguishing all the apparently numerous subtypes and varieties from such insufficient and unsatisfactory data as are available. However, three or four clear-cut regional phases are indicated here, though their areal limits as shown on the map are hypothetical where drawn in broken lines.

The tendency to February fog, common in these regimes, is probably *radiational;* it is also found east to the Great Lakes, and westward in Montana it becomes predominant (Montana regime, below). The late-winter and spring fog near the Rocky Mountain front is probably largely orographic, though other kinds certainly enter in; eastward the spring fog is due more to a combination of *radiation, frontal,* and *advection fogs.* The September and October fog is, of course, largely *radiational;* in the valleys of Minnesota and the Dakotas it generally forms the primary maximum of the regime, but on the plains between the streams it seems to be secondary to the November or spring fog. The November fog is probably the overlapping of the *radiation, frontal,* and *advection* influences, but its greater relative prominence on the uplands, where it is often the chief maximum, suggests that it is mostly due to the latter two influences.

The summer minimum is the most consistent feature of these regimes. Phases: (*a*) *Minnesota-Dakota regime* [22]: September-October maximum in valleys, October-November on uplands; February or April secondary maxima; (*b*) *Canadian Plains regime* [23]: South of northern Saskatchewan Valley; similar to Minnesota-Dakota regime but with tendency to more summer fog (*radiation?*) northward and to more February or November fog; (*c*) *Cheyenne regime* [24]: March-May maximum, September and winter secondary maxima; this type may recur near the Rockies in Alberta, but if so there are not enough data to locate it.

3. Montana regime [25]: December and February maxima (one or the other slightly the greater), also September-November secondary maxima in places; some of the midwinter fogs are of the "pogonip" (ice) *radiation* type.
4. Mackenzie-Yukon Basin regime: North from the northern Saskatchewan Valley. July-October maximum; winter secondary maximum in some places (?); earlier maximum in higher latitudes.

B. Types whose maxima are the result of *advection* (*Tropical air*), *frontal* (mostly *prefrontal*), and *radiation* (*ground* and "valley") *fogs* combined in various proportions, no one kind predominating very largely; also on the High Plains and the Piedmont orographic fogs or influence.

1. Southern and Central Plains regimes: Winter maxima, summer minima, in the South generally no summer fog.

   Phases: (*a*) [26] Winter maximum (December or January), summer minimum, regular curve; (*b*) [27] Winter maximum, October (occasionally September) secondary maximum; (*c*) [28] Winter maximum, March or April secondary maximum; (*d*) [29] Winter maximum, October (occasionally September) and March secondary maxima.

C. Types whose maxima are due to various proportions of *radiation* (*ground* and "valley"), *maritime*, *high*, and *frontal* (especially *prefrontal*) *fogs*.

1. California Great Valley regime [30]: December, occasionally January, maximum; no summer fog.
2. Puget Sound-Willamette Valley regime[34] [31, 32]: September-October maximum, July minimum; same as California Great Valley regime except for earlier maximum due to higher latitude and a little summer fog; November maximum around Portland [32] due to effects of Columbia Gorge (east) winds.
3. British Columbia-Alaska Fiord regime [33]: October maximum, advancing to September maximum in Alaska; spring, summer, or winter secondary maxima in places; the decrease after the maximum is gradual, since there is generally much winter fog; the late spring and summer are commonly the least foggy seasons. This regime is probably related to the two preceding regimes; the maxima of all three seem to be dependent on the beginning of the rainy season, when frequent cyclonic passages import fresh maritime air to the land and radiation quickly fogs it; the winter fog is more *prefrontal* (except in California).
4. Intermountain regimes: Transitional between West Coast regimes and those of the interior plains. Winter maxima; little or no summer fog; the *maritime fog* influence is small and is limited to the western part of the region.

   Phases: (*a*) *Spokane transition regime* [34]: November-December maximum, no summer fog; the early-winter maximum results from the effect produced by the Columbia River Gorge in allowing some of the maritime influence of the Puget Sound-Willamette Valley regime to penetrate inland to an unusual extent;[35] (*b*) December maximum; occurs at scattered stations; (*c*) January maximum [35]: Subtypes: (1) [36] With March-May secondary maximum; (2) *Fraser Basin regime* [37]: With autumn or spring secondary maxima in places, practically no summer fog; (3) *Rio Grande Basin regime* [38]: January or December maximum, with September-November secondaries (*radiation fog*?); the November tendency becomes more pronounced on the plateau of northeastern Mexico.

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[34] A. B. Carpenter: Fog at Portland, Ore. (unpublished manuscript); *idem:* Record November Fog . . . in the Pacific Northwest, *Monthly Weather Rev.*, Vol. 62, 1934, pp. 404-407; also personal communications.

[35] Carpenter, Subsidence in Maritime Air over the Columbia.

III. Littoral Regimes

A. Eastern littoral regimes.

1. Northeastern Inner Fiord regime: At some sheltered locations only; spring maximum, summer or autumn (and midwinter?) secondary maximum.
2. Gulf of St. Lawrence-Newfoundland regime [39]: Spring maximum, autumn secondary maximum; winter minimum.
3. New England-Maritime Provinces regime [40]: Autumn (usually September) maximum, spring, or summer, and winter secondary maxima.
4. Northern Coastal Plain regimes [41]: Buzzards Bay, Mass., to Cape Charles, Va. These form an unusually extensive group of littoral varieties of great diversity and complexity, since two water regimes and three land regimes are involved, and the conditions are favorable for penetration of the marine influences to a great distance inland. The maximum can come in almost any month, since there are marked tendencies to fog in every season, which appear in various degrees of relative and absolute amount at different places.[36] There is consequently so large an element of uniqueness in the regime at each station that only the broader contrasts can be generalized. Thus near the shore spring, or early and late-summer, tendencies due to *sea fogs* and *monsoon fogs* are prominent but decline or disappear inland, more rapidly on the lowlands and the land in general than over the bays. Inland, in low spots and valleys, summer fog due to radiation is frequent in moist ocean air that may have been foggy at sea or nearer the shore. An autumn tendency is well marked back from the shore, which indicates it is in large measure due to *radiation fog* (including some *maritime fog*). There is in autumn some *frontal* and land *advection fog*, too. The winter fogginess is often the most prominent and seems to consist of two phases, one a tendency to early-winter (December-January) fog and the other a tendency to late-winter (February-March) fog. The late-winter fog seems to be largely littoral and a reflection of the influence of the Hatteras and March-maximum phases of the Western Atlantic winter regime. But the March fog may also be of the land type of Phase c of the Southern Plains regime. The early-winter fogginess is the expression of the winter maximum of the Southern Plains regime. The regimes over Chesapeake and Delaware bays and the Carolina sounds are not known, but probably they have the May-June advection tendency characteristic of the shore waters and the winter fog of the land minus the *radiation fog* component.

   Phases: (*a*) May-August maximum; secondary maxima in autumn, midwinter, and March (near shore; lowlands); (*b*) Autumn maximum; secondary maxima in winter and late spring or summer; (*c*) January (or December) maximum; March, autumn, and April-June secondary maxima (March or autumn secondaries sometimes missing); (*d*) March maximum; secondary maxima in April-June, early winter, or autumn; (*e*) February maximum; secondary maxima in April-June, early winter, and sometimes autumn (at some shore stations from Long Island south; due to the influence of the Hatteras regime?).
5. Southeastern and Gulf Coastal Plain regime [42]: This includes the part of the coastal zone that experiences the winter invasion of warm-air *advection fogs* formed over the sea or the Gulf of Mexico. The landward boundary is only guessed at, since it is not known how far inland these fogs penetrate in appreciable numbers; the maximum of the normal continental fogginess and that of the ocean or Gulf fogginess come at the same time, so that pre-

[36] Willett, Synoptic Studies in Fog (see footnote 3) is a careful study of the fogs at a locality in this regime (Hadley Airport, New Jersey).

sumably the belt of increased fogginess along these coasts (see Fig. 1) is due to the littoral effect of water fogginess added to that of the land.

Subtype: (*a*) [43] With March secondary maximum due to the influence of Subtype a of the Gulf of Mexico regime. There is a suggestion of this tendency on the South Carolina-Georgia Atlantic coast, where the influence of Phases b, d, or e of the Western Atlantic winter regime is probably felt [42].

B. West Coast littoral regimes.

1. British Columbia-Southern Alaska regime: September maximum (August in Alaska), spring or winter secondary maxima in places; limited to a very narrow zone on the outer coast.
2. Puget Sound to Point Arguello (California) regime [44].

   Phases: (*a*) September-November maximum, January-February secondary maximum, and also May-August secondary maxima in places; occurs at low elevations near shore, up to 500 feet; (*b*) July-August-September maximum; winter minimum; occurs at elevations from 500 to 2000 feet on coastal mountains; due to "velo clouds" and lifted *sea fogs*.
3. Southern California Piedmont regime[37] [45].

   Phases: (*a*) June maximum, September-November and February secondary maxima; occurs back from shore at elevations up to 800 feet; (*b*) September-November maximum, June and February secondary maxima; at low elevations near shore; (*c*) July-September maximum; winter minimum (?); at elevations from 800 to 3500 feet; due to "velo clouds" and lifted *sea fogs*.
4. Lower California Foggy Desert regimes[38] [46].

   Phases: (*a*) Autumn maximum, spring and winter secondary maxima (?); at low elevations; (*b*) Summer maximum; at higher elevations, to 4000 feet in north and 1500 feet in south; due to "velo clouds" and lifted *sea fogs*.
5. Gulf of California littoral regimes.

   Phases: (*a*) Eastern shore: spring maximum; winter secondary (?); (*b*) [47] Western shore[39]: winter maximum; spring secondary (?).

C. Sub-Arctic littoral regimes.

1. (See Northeastern Inner Fiord regime, above.)
2. Bering Sea regime (eastern shore): Late-spring or early-autumn maximum (?); winter secondary maximum (?).
3. Arctic Sea regime (land littoral only): Early-summer or early-autumn maximum (?); winter secondary maximum (?).
4. Hudson Bay littoral regime (also littoral of Great Bear, Great Slave, and Athabaska lakes): May-June and August-September maxima; winter minimum and July secondary minimum.

IV. Great Lakes Regimes

A. Regimes of the Great Lakes proper.

1. Northern Great Lakes *monsoon fog* regime: Late-May or June maximum; winter minimum.

   Phases: (*a*) Lake Superior regime [48]: June maximum, September secondary maximum in places; winter minimum; (*b*) [49] With March and

[37] B. M. Varney: Fog Phenomena of the Piedmont Littoral West of Los Angeles, *Bull. Amer. Meteorol. Soc.*, Vol. 14, 1933, pp. 125–126.

[38] E. W. Nelson: Lower California and Its Natural Resources, *Memoirs Natl. Acad. of Sci.*, Vol. 16, No. 1, 1921, pp. 100–101.

[39] *Ibid.*

October (or September) secondary maxima; also winter tertiary maximum in places due to steam fog.

2. Southern Great Lakes *moonsoon fog* regime [50]: April-May maximum, autumn and winter secondary maxima in places; probably same as windward-side regime (see below), except that the spring fog is here more prominent.
3. Southern Great Lakes windward-side regime [51]: May maximum, October (or November) secondary maximum, winter tertiary maximum in places; July minimum.
4. Southern Great Lakes lee-side regime: Double maximum, May and October; tertiary winter maximum at some places; July (but sometimes winter) minimum.

   Phases: (*a*) [52] October maximum slightly greater than May maximum; (*b*) [53] May maximum slightly greater than October maximum (colder waters); (*c*) [54] Over bays spring fog largely disappears.
5. Lake Erie-Lake Ontario north-side regime [55]: Autumn (October) maximum, May secondary maximum, also generally winter tertiary maximum; decided summer minimum. This is a special case of the lee-side regime.
6. Lake Erie south-side regime [56]: March-April maximum, January and October secondary maxima (these may be lacking at some places); summer minimum. This is a special case of the windward-side regime where the seasons are earlier and the autumn tendency is rather abortive owing to the northern exposure.

B. The Great Lakes littoral regimes: The distribution is too small to show much of it separately on the map (Fig. 2).

1. Lake Superior littoral regime: September maximum, June and sometimes also winter (December or February) secondary maxima.
2. Southern Great Lakes regime: Generally very similar to the shore-water regimes (A3 to A6 above); the autumn fog apparently extends farther onshore than the spring fog, though it usually occurs less frequently.[40]
3. Lake Erie south-shore regime [56, 57]: At low elevations near the shore the regime is the same as over the shore waters [56], but on uplands back from the shore winter fogginess increases and spring fogginess decreases; in winter (November-March) northeast to west winds make the warm lake a continual source of low strato-cumulus clouds,[41] which sometimes build down to the water or shore as light fog (rarely dense) but bring much dense fog to elevations several hundred feet or more above the lake and for many miles to the south and east [57].

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[40] Any tendency to spring fog well back or many miles from the shore is probably due to radiation effect on the moist air from the lake.

[41] This phenomenon is well known on all the lower lakes, but only here does it greatly affect the *dense* fog regime of the littoral; over the central and leeward parts of the southern lakes there may be a number of days with more or less dense "steaming" each winter, but this becomes low strato-cumulus clouds on the windward sides (see C. L. Mitchell: Snow Flurries along the Eastern Shore of Lake Michigan, *Monthly Weather Rev.*, Vol. 49, 1921, pp. 502–503; also Willett, American Air Mass Properties, p. 22).

A VARIABILITY SERIES OF ISOCRYMAL MAPS OF NEBRASKA

Earl E. Lackey
University of Nebraska

IN those parts of the world where frost and the length of growing season are limiting factors in crop production a knowledge of probabilities relative to the last killing frost of spring and the first killing frost of autumn is highly desirable. The safest criterion to follow in such areas is the detailed record of what has actually occurred.

Several series of isocrymal (equal-frost) maps for Nebraska showing the mean dates of the last killing frost of spring and the first killing frost of autumn have been constructed by the United States Weather Bureau at Lincoln. The earliest of these appeared in the *Annual Report of the State Board of Agriculture* in 1909. At that time the average length of frost records for the weather stations of Nebraska was only 11 years; hence the maps were little better than rough approximations.

In making a new series of isocrymal maps the present investigator considered it more desirable to use the median and percentile dates rather than dates calculated from means and standard deviations. Not only is the former method easier to manipulate, but the resulting maps more nearly approximate what has actually occurred.[1]

Finding Median and Percentile Dates

At Lincoln, Nebraska, the median date of the last killing frost in spring is April 18. This date is based on what has happened during the past 37 years and was worked out in the following manner.

On a special calendar for March, April, and May the date of the last killing frost of spring was checked for each of the 37 years from 1897 to 1933. Counting forward from the earliest date (March 27), one finds that the median date, i.e. the 50-percentile or 19th date, falls on April 18. From this one may count forward or backward to find any other desired percentile date. For the purposes of this study the 20, 40, 50, 60, and 80-percentile dates were computed. The positions of these dates are shown to be April 25, April 19, April 18, April 17,

[1] The reliability of a series of maps of this kind is limited by many factors, among which the following may be noted: (1) The short period of time that the records have been kept. The length of record ranges from 20 years to 61 years; the average length is 36 years. (2) Errors in observation. These are especially liable to occur in the spring when the response of vegetation to freezing usually is not so noticeable or so crucial. (3) The relative weight to be given to short-time and long-time records. As interpolation of the record was risky, it was not attempted in any way. (4) The discarding of the earliest year when the recorded number of years was even. This was done in order to have the median fall in the middle of a day rather than at midnight, i. e. between two days. Fractional parts of a day were thus more easily disposed of when percentile dates were being calculated.

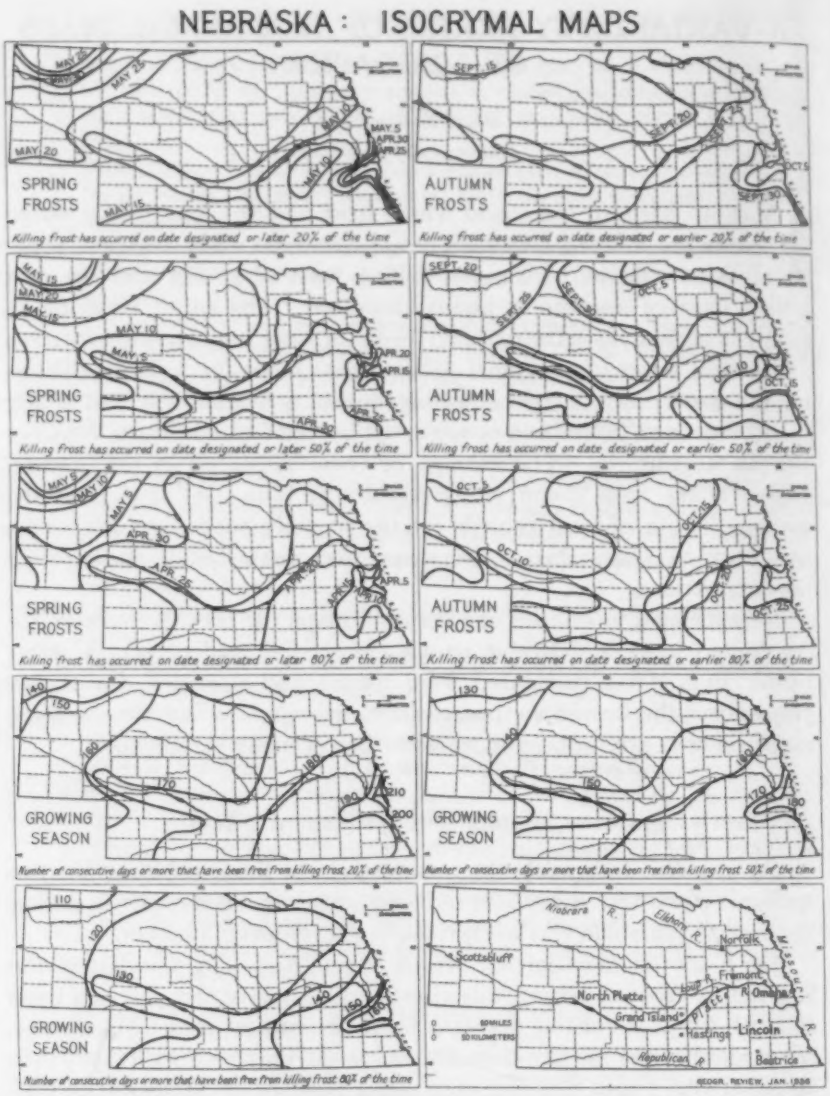
NEBRASKA: ISOCRYMAL MAPS
SPRING FROSTS
Killing frost has occurred on date designated or later 20% of the time
AUTUMN FROSTS
Killing frost has occurred on date designated or earlier 20% of the time
SPRING FROSTS
Killing frost has occurred on date designated or later 50% of the time
AUTUMN FROSTS
Killing frost has occurred on date designated or earlier 50% of the time
SPRING FROSTS
Killing frost has occurred on date designated or later 80% of the time
AUTUMN FROSTS
Killing frost has occurred on date designated or earlier 80% of the time
GROWING SEASON
Number of consecutive days or more that have been free from killing frost 20% of the time
GROWING SEASON
Number of consecutive days or more that have been free from killing frost 50% of the time
GROWING SEASON
Number of consecutive days or more that have been free from killing frost 80% of the time
Niobrara R.
Elkhorn R.
Norfolk
Scottsbluff
Fremont
North Platte
Omaha
Grand Island
Hastings
Lincoln
Republican R.
Beatrice
50 MILES
50 KILOMETERS
GEOGR. REVIEW, JAN. 1938

FIG. 1—A series of maps showing frost variability in Nebraska. In addition to the maps reproduced here the author has prepared 40 and 60-percentile isocrymal maps for spring and autumn. (Photostat copies may be obtained for 25 cents from the American Geographical Society.) Scale of maps 1 : 14,000,000.

and April 12 respectively. These dates signify that a killing frost has occurred at Lincoln on April 25 or later 20 per cent of the time, on April 19 or later 40 per cent of the time, etc.

The same procedure was followed for each of 71 other stations in Nebraska. No station with a record of less than 20 years was included in the study. The longest record was that of Omaha, 61 years.

Isocrymal Maps for Spring

With these computations at hand, the 50-percentile or median dates for the last killing frosts of spring were entered on an outline map of the state (Fig. 1) and isocrymes drawn at intervals of five days. An isocryme on this map means that the last killing frost of spring has occurred on the designated date or later 50 per cent of the time.

The 20, 40, 60, and 80-percentile isocrymal maps for spring (Fig. 1) are more important perhaps than the 50-percentile or median map. On these maps the isocrymes pass through those places where the last killing frost of spring has occurred on the designated dates or later 20 per cent of the time, 40 per cent of the time, 60 per cent of the time, and 80 per cent of the time. For example, 20 per cent of the time at Lincoln the last killing frost of spring has occurred on April 25 or later, whereas 80 per cent of the time it has occurred on April 12 or later.

A farmer in the vicinity of Lincoln, knowing that early potatoes as a rule bring high prices or mature before the hot season arrives, may use the spring isocrymal maps to advantage. If he thinks that planting potatoes early and taking a chance with frost are better than risking a low price, he may prefer to plant so that the potatoes will be up on April 12 with a hazard of 80 per cent, rather than to plant so that they will just be coming up on April 25 with the hazard only 20 per cent.[2]

By consulting the variability maps for spring the farmer may learn that he is taking a 20 per cent chance that his corn will be frosted if it is up on April 25. But he knows also that corn planted on April 25 is usually up by May 5—none too late for a good crop prospect. Or he may wish to take a 20 per cent chance on one-third or one-fourth of his crop, knowing that unseasonable dry or cool weather or rains may interfere with the later planting. Thus by intelligently taking the frost hazards into consideration he may succeed in his farming operations a large part of the time.

Isocrymal Maps for Autumn

The median and percentile dates for autumn were also computed and maps constructed as for the spring.

A cattle feeder may desire a large, late-maturing variety of corn for ensilage. The variability isocrymal maps for autumn show him the percentage of frost hazard to such varieties when planted at different dates. In selecting seed corn from the standing stalk in the autumn, if he accepts as a criterion what has happened in the past, the farmer can make an intelligent guess about the approximate date on or before which such work should be completed.

[2] It is recognized, of course, that there is a germination hazard connected with soil temperature that the temperature record above ground does not take into account.

Isocrymal Maps of Growing Season

The data given in the records of the United States Weather Bureau were used for the construction of the 20, 50, and 80-percentile maps showing the periods free from killing frosts in different parts of Nebraska (Fig. 1). The numerals on the lines running through the 50-percentile map indicate the minimum number of consecutive days that are free from killing frost 50 per cent of the time. Lincoln, for example, has a frost-free period of not less than 160 days 50 per cent of the time. The 20-percentile and 80-percentile maps are to be interpreted similarly.

The dairyman who depends on forage crops for pasturage for his cows wants to know what percentage of the year will be free from killing frosts. If he is a careful planner, he may consult the maps on length of growing season for the percentage of hazard involved.

Some Conclusions

It is not contended that this series of maps may be used to forecast what frost conditions in Nebraska will be, but it does give a summary of what the conditions have been in the past. Only to the extent that the record of the past may be used as a criterion in forecasting the future may the maps be utilized for prediction. The maps show that in spring there is a spread of about 20 days in the eastern part of the state between the 20-percentile and 80-percentile maps, whereas in the western part the spread is only 15 days. This indicates that, although spring begins later in the western part of the state, it advances more rapidly there. In the autumn the spread between the 20-percentile and 80-percentile maps is about 20 days in both the eastern and the western parts of the state. This indicates that the season advances in autumn at about the same rate in both regions.

THIRD INTERNATIONAL CONGRESS OF SOIL SCIENCE

Charles F. Shaw
University of California

THE Third International Congress of Soil Science[1] was held at Oxford, England, July 30 to August 7, 1935, and was followed by a soil-study excursion from August 8 to August 23. Four hundred and twenty-seven delegates were registered, 324 from outside Great Britain. Thirty-four independent nations and 24 dominions, colonies, and dependencies were represented. One hundred and forty-six participated in the soil-study excursion, most of these being the foreign delegates. The Congress met in plenary session each forenoon, and the afternoons were devoted to the meetings of the commissions: (1) Soil Physics, (2) Soil Chemistry, (3) Soil Microbiology, (4) Soil Fertility, (5) Soil Genesis, Morphology and Cartography, (6) Application of Soil Science to Land Amelioration.

Papers of interest in geography were presented at the first plenary session by the President, Sir E. J. Russell, "The Place of Soil Science in Agriculture," and by G. W. Robinson (Wales), "Soils of Great Britain." In the meetings of Commission 5, among many papers of geographical significance the contributions of G. Milne (Tanganyika) and his associates on the soils of East Africa and of C. R. van der Merwe (Transvaal) on the soils of South Africa were of particular interest because they covered regions from which there has been very little soil information. Papers by James Thorp (China) and T. Y. Tang (China) extended the information regarding the soils of China, and several brief papers presented studies of soils in different parts of the world.

H. Stremme (Danzig) exhibited a large map of the soils of Europe (on the scale 1 : 2,500,000) compiled from the most recent available data and showing the soils in inclusive categories such as podsols, brown earths, chernozems, and the like, according to the "Russian" classification. This map is to be published in twelve sheets and is expected to be available early in 1937. E. H. del Villar (Spain) exhibited a large-scale map (about 1 : 500,000) of the Iberian Peninsula on which, by color and symbols, were shown the soil origin, degree of leaching and reaction, and the texture of surface soils and subsoils. It is not probable that this map will be published, unless on smaller scale. The late Dr. C. F. Marbut (U. S. A.) exhibited the "Soil Map of the United States" (scale 1 : 2,500,000) recently published by the United States Department of Agriculture as part of its "Atlas of American Agriculture."

The discussions indicated that soils are being mapped in many parts of the world and that the work seems to be about evenly divided between broad regional mapping on the so-called "climatic" or "Russian" basis and the more detailed studies on the "American" basis. Both methods are being more or less modified to meet local conditions. With the work already under way and that projected, as reported by the delegates, maps showing the distribution, and texts giving descriptions, of the soils of the world will rapidly become available. Interest is very general in the classification of soils on an economic basis, and many such projects were announced. Such work, to be of sound value, requires detailed soil information that can be supplied only by soil surveys; hence demands for soil maps are intensified. One session was devoted to the methods and problems of land classification, with papers by G. Görz (Germany), T. D. Jarvis (Canada), L. Kreybig von Madar (Hungary), and C. E.

[1] On the First International Congress of Soil Science, which was held in Washington, D. C., in 1927, see Dr. C. F. Marbut's report in the *Geogr. Rev.*, Vol. 17, 1927, pp. 661–665; on the second congress, held in Russia in 1930, see the present writer's report, *ibid.*, Vol. 21, 1931, pp. 146–148.

Kellogg and C. F. Marbut (U. S. A.). Each used as basic data the facts supplied by the detailed soil maps.

Most of the papers read at the Congress were included in Volume I, Commission Papers, and Volume II, Plenary Session Papers,[2] which were printed and distributed before the meetings. With these papers in the hands of the audience, the authors presented briefly the gist of their arguments and conclusions, and the delegates entered vigorously into the discussions. The few papers that were not printed in advance of the meetings will be included, with other material (elections, resolutions, etc.), in Volume III, to be issued shortly.

The Fourth Congress will be held in Germany in 1940. Dr. F. Schucht (Germany) was elected president, Dr. C. F. Marbut (U. S. A.) and Dr. A. A. Yarilov (U.S.S.R.) vice-presidents, and Dr. D. J. Hissink (Holland) general secretary and treasurer.

Exhibits

The exhibits at the Congress consisted mainly of monolithic soil profiles of excellent quality and character. Most noteworthy were those of English soils presented by Oxford University, the University of Bristol, and the South-Eastern Agricultural College and the excellent monolithic profiles of African soils presented by Morison, by Milne, and by Van der Merwe. The profiles of a number of Chinese soils were presented by horizon samples and by full-size colored photographs, the "rice-paddy" soils being especially interesting in showing a podsolic type of profile evidently developed since the soils have been used for rice.

Excursions

During the progress of the meetings at Oxford several short excursions were made in the vicinity, and after the close of the formal meetings the Post-Congress Excursion took the delegates to Wellington (near Shrewsbury), thence to Bangor in North Wales, to Perth, Aberdeen, and Edinburgh, and to Newcastle, York, and Cambridge. The party spent from one to three days at each of these places and made trips to the adjacent country where soil profiles had been prepared in advance either as dug pits or in a few cases as prepared exposures in quarries and road cuts. In addition, one small party went by air from Aberdeen to the island of Lewis to study the progress of peat reclamation in the Hebrides. At each of the locations both cultivated soils and forested soils were observed and studied and comparisons made of the changes that may be produced by cultivation or afforestation.

Throughout the entire region studied the most striking pedological feature is the youthful stage of soil development. If soils are compared to men and a fully mature man is placed at age 60, most of the well drained soils observed show ages equivalent to about 15 and not more than 20 years. There was evidence of clay accumulation in the subsoils of most of the profiles, but in none had this progressed to even a semi-mature stage. This youthfulness in profile seems to be due to the relatively brief period since the recession of glacial ice and to the relatively low intensity of soil-developing factors. The primary soils showed very markedly the influence of parent material that in various locations consists of rocks, from sandstones, shales, and chalks to granites. Many profiles showed soils derived from boulder clay and other glacial drift, but here again local rocks influence markedly the character of the glacial deposits. In their development the soils generally showed podsolic characteristics though through much of England the delegates discussed the question of whether or not the soils belonged in the brown-earth group.

The profiles in the grasslands and to some extent in the forests are being modified by the action of earthworms that "till" the upper horizons and tend to destroy or

[2] *Trans. Third Internatl. Congr. of Soil Science, Oxford, England, 1935*, Vols. 1 and 2, London, 1935.

counteract the development of the bleached horizon. In the "Park Field" at Rothamsted is definite evidence that the upper four inches of the soil consists of material brought up by worms. Many of the profiles have also been modified by the action of man by cultivation, by removing the forests and maintaining a grass cover, and by liming. It was the opinion of most of the delegates that the soils studied are in no place representative of the true brown earths as established by Ramann but that instead they are podsolic, though there are very few typical podsols. The relatively low precipitation in much of central and southern England seems to be offset by the even seasonal distribution and gentle character of the rainfall, which permit most of the water to enter the ground and become effective for soil development as well as for plant growth.

In a brief trip to the vicinity of Canterbury after the close of the excursion one exposure was examined of a relatively shallow soil formed by residual weathering of chalk. This showed a more fully developed profile than any previously seen and also showed markedly the effect of low rainfall and grass cover. In the subsoil just above the broken and fragmental parent rock there is an evident zone of lime accumulation, a characteristic that ordinarily is found only in soils of arid regions. If this one profile is representative of this district, it would indicate that the low rainfall in this region (about 20 inches) is used up so rapidly by the grass that leaching is limited and a soil profile with "arid" characteristics developed.

Although the excursion was devoted primarily to the activities of Commission 5, Soil Genesis, Morphology and Cartography, considerable attention was paid to the subjects of soil fertility and soil improvement by drainage and other methods of reclamation. The variation in the soil profiles studied was not wide, but the excursion afforded an excellent opportunity for studying the minor modifications in soils existing under relatively uniform conditions of climate and cover.

AMERICAN GEOGRAPHICAL SOCIETY

The November Meeting and Presentation of the Society's Medals. The regular monthly meeting of the American Geographical Society was held on November 26, 1935, at the Engineering Societies' Building, 29 West 39th Street, President Redmond in the chair. The meeting was the occasion of the presentation of the Society's medals. After a prefatory welcome to the Society's distinguished guests President Redmond made the presentations—the Charles P. Daly Medal for 1935 to Dr. Roy Chapman Andrews, Director of the American Museum of Natural History, the Cullum Geographical Medal for 1935 to Professor Douglas Johnson of Columbia University, and the David Livingstone Centenary Medal for 1935 to Consul Lars Christensen of Sandefjord, Norway. The citations were as follows:

ROY CHAPMAN ANDREWS

Two elemental instincts have come down to us from our Stone Age ancestors: the instinct to create and the instinct to explore. The two are akin, and without them humanity would never have risen out of savagery. Perhaps this is the chief reason why society takes special delight in doing honor to the artist, the poet, the scientist, and the explorer.

The instinct to explore has been an irresistible force in Dr. Andrews' life. He opens his latest book with these words: "I was born to be an explorer. There never was any decision to make. I couldn't do anything else and be happy." And yet merely to feel and follow the lure of the unknown are not enough to qualify one as an explorer today. Dr. Andrews' distinction lies in what he has done to develop new conceptions and new techniques of exploration. The day of the lone explorer who merely gathers impressions by passing through an unknown country is over. So too is the day of the uncoördinated expedition on which scientists in their several fields pursue each his own independent studies. In his expeditions in Central Asia Dr. Andrews has demonstrated the importance of correlated work as the basis of the scientific organization of his field parties. It is indeed a tribute to his genius for leadership that his expeditions have operated as closely knit teams and that an immense harvest of scientific results has been gathered in the form of collections for the laboratory, the workshop, and the exhibition halls of civilization.

Dr. Andrews' name is indissolubly linked with a great institution and with a vast region. Nearly thirty years ago he joined the staff of the American Museum of Natural History, and today, as we all know, he is its Director. The vast region with which we associate his name, much as we associate the name of the late Colonel Lawrence with Arabia, is of course Mongolia. Thanks largely to Dr. Andrews' work, the wild plains and wind-swept uplands of Mongolia may no longer be regarded as among the least-known parts of the earth's surface.

To Dr. Andrews—Andrews of Mongolia—it is my privilege to present, on behalf of the American Geographical Society, the Charles P. Daly Medal, awarded from time to time by the Society "for valuable or distinguished geographical services or labors."

DOUGLAS JOHNSON

Professor Johnson is the leading exponent in this country of the science of physiography. His work in the interpretation of land forms and topographic features has encompassed the whole expanse of the United States, from the tilted block of the Sierras, the overthrust folds of the Rockies, and the mighty erosional gorge of the Grand Canyon to the rivers and valleys of the Appalachians and the beaches and estuaries of the Atlantic coast.

His investigations have also carried him far from home—to South Africa, to the

East Indies, to Australia—and the knowledge acquired on these foreign expeditions has imparted to his studies of the domestic scene the quality of world perspective.

Dr. Johnson's work has not been restricted to the scholar's chamber. Keenly conscious of science's obligation to society, he has given freely of his time and technical knowledge to undertakings concerned with the public welfare. The protection of the coast of New Jersey from the attacks of the sea, the continued need for which was again demonstrated only ten days ago; the settlement of the dispute about the boundary between Canada and Labrador; the coördination of the mapping services of the federal government with a view to expediting the completion of our topographic map—these are all problems that have had the benefit of his keen analysis and indefatigable search for truth.

During the early years of the World War Professor Johnson closely followed the military campaigns and the influence of the terrain on their conduct. With the entry of the United States into the conflict and his appointment by the Secretary of War to special service abroad came opportunity for observation at first hand, which led to the publication, under the Society's imprint, of a book on the "Battlefields of the World War." At the conclusion of the struggle his talents were again required by the government, and he rendered it conspicuous service as Chief of the Division of Boundary Geography of the American Commission to Negotiate Peace.

Professor Johnson, it is a pleasure to present to you, on behalf of the American Geographical Society, the Cullum Geographical Medal, awarded to those "who distinguish themselves by geographical discoveries, or in the advancement of geographical science."

LARS CHRISTENSEN

The name of Consul Lars Christensen of Sandefjord is written large over two spheres of endeavor—the organization of whaling as a modern industry and the unrolling of the map of the Antarctic.

From its earliest days whaling has inevitably been associated with exploration, but too seldom have whalers been able or willing to make known their discoveries to the world of science. There have, however, been some notable exceptions to this rule. In the early 1800's an English whaler and his son, the Scoresbys of Whitby, made scientific observations of such importance that their work has been described as the "foundation stone of Arctic science." About the same time the Enderby brothers, merchants of London, were dispatching whalers and sealers to the South Polar regions, where Enderby Land commemorates the famous voyage under Biscoe in the 1830's. To these names of shining examples of the honorable association of the whaling industry and science must be added that of Consul Lars Christensen.

Since early youth Consul Christensen has been familiar with the whaling industry. He was brought up in a home where the discussion of whaling and polar matters was an every day occurrence. In 1892, when he was still a boy, his father, Christen Christensen, sent out the *Jason* to the whaling banks of the Antarctic. That year and the next the *Jason* brought back a harvest of scientific results and also laid the foundation for the modern whaling industry in the Antarctic, which began in 1905 when Christen Christensen sent thither the first pelagic whaler.

Consul Lars Christensen has followed in his father's footsteps. He has maintained a continuous program, not only for scientific studies of the whaling grounds in the Antarctic but also for the collection of data on the life and habits of whales as the basis for an intelligent exploitation of a natural resource of international concern.

He has, likewise, established the Commodore Christen Christensen Whaling Museum at Sandefjord, which is engaged in active scientific work relating to whaling. One of the most important aspects of the work of this institution is the collection and compilation of maps based on new data reported by whalers, and, we may add, the Museum has been generous in its donations of such maps and data to our Society.

Consul Christensen has done us the very great honor of making the trip from Norway to New York especially to receive the David Livingstone Centenary Medal and to tell us of his experiences. He has not been content with initiating, organizing, and supporting scientific voyages. He has gone down to the Antarctic to see for himself, and he can speak at first-hand of that strange and awesome region.

Consul Christensen, it gives me great pleasure to present to you, on behalf of the American Geographical Society, the David Livingstone Centenary Medal, "awarded for scientific achievement in the field of geography of the southern hemisphere."

After the presentations Consul Christensen delivered a lecture on "Recent Norwegian Exploration in the Antarctic," describing in particular the series of expeditions that he has himself sent out to the Antarctic during the last ten years and his own experiences on three voyages, on one of which all previous records were broken in that sector by reaching 71° 44′ south latitude. The results of some of the expeditions have appeared in the *Geographical Review* (see especially Gunnar Isachsen: Modern Norwegian Whaling in the Antarctic, Vol. 19, 1929, pp. 387–403, and Norwegian Explorations in the Antarctic, 1930–1931, Vol. 22, 1932, pp. 83–96; and Hjalmar Riiser-Larsen: The "Norvegia" Antarctic Expedition of 1929–1930, Vol. 20, 1930, pp. 555–573), and Consul Christensen has himself written of them in his book "Such is the Antarctic" (reviewed in this number of the *Geographical Review*). The lecture was illustrated with still and motion pictures including an interesting film showing details of the whaling operations.

Recent Publications

Chile: Land and Society. In January, 1936, the Society will publish a volume by Dr. George M. McBride entitled "Chile: Land and Society" (*Amer. Geogr. Soc. Research Ser. No. 19*).

Nowhere in the western hemisphere is there a wider gap between the upper and lower classes than in Chile. The upper class derives its wealth and prestige from ownership of the land. Most of the great estates, or haciendas, had their beginnings in land grants of the colonial period, and many of them have been maintained almost intact in the same families down to the present time. By far the greater part of the productive farm and pasture land of the country is included in the haciendas. The great proprietors are men of education and culture. Leaders in the political life of the nation and men of the world, they seldom reside permanently on their estates, the management of which is usually left to salaried administrators. The rural population consists mostly of *inquilinos* or tenants, a patient, sturdy folk who have remained for generations in ignorance and poverty. Strong currents of unrest, however, are stirring in city and country alike. The experiences of Russia and Mexico have shown that a system that permits the existence of great estates with an underprivileged tenant class is an anachronism in these modern times, and Dr. McBride sees the menace of violent revolution unless the landowners lead the way to far more radical reforms than have as yet been attempted.

Dr. McBride, who is professor of geography at the University of California at Los Angeles, knows Chile at first hand through long residence in that country. His volume is based on personal observations and on research in the Chilean libraries, archives, and government offices. He presents a vivid picture of life on typical rural properties of different kinds. He discusses in detail the origins and development of the hacienda system and analyzes the place of this system in the economic and social structure of the nation and the influence of the *hacendado* class in the political life of Chile. The volume also contains interesting accounts of certain Indian agrarian communities where pre-Spanish forms of land tenure have persisted, of new white colonization in the forest regions of the south-central part of Chile, and of the recent development of great ranches in the far south.

Dr. McBride is an authority on questions of land tenure in Hispanic America. The Society published in 1921 a short study by him on "The Agrarian Indian Communities of Highland Bolivia" (*Research Ser. No. 5*), which was followed in 1923 by "The Land Systems of Mexico" (*ibid., No. 12*).

The Colorado Delta. The Society is publishing jointly with the Carnegie Institution of Washington a volume by Mr. Godfrey Sykes entitled "The Colorado Delta."

The delta region of the Colorado River has long been of interest because of both its agricultural utilization by man and its physical geography: mere mention of the names "Imperial Valley" and "Salton Sink" is sufficient advertisement. The recent completion of Boulder Dam and the resulting control of the river inaugurate a new epoch in the physical history of the delta and make this an opportune time to take stock of its present condition and previous development. For this task Mr. Sykes has exceptional qualifications. He has been associated with the Desert Laboratory of the Carnegie Institution at Tucson, Arizona, since its establishment in 1903, and his personal acquaintance with the delta goes back another twelve years.

The book consists of three parts. The first deals with the history of the region, from the discovery of the river mouth in 1539 by Francisco de Ulloa to the expedition of Lieutenant J. C. Ives, in 1857–1858, which ushered in the era of river navigation to Fort Yuma, terminated in 1876 when the completion of the Southern Pacific Railroad made unprofitable the long journey from San Francisco around Lower California to the mouth of the river.

The second part discusses in detail by ten-year periods since 1890 the physiographic history of the delta region. The lower river is seen to have passed during this time first through the concluding phase of a protracted stable period, then through a great lateral diversion toward the western and still unfilled portion of the area available for dispersal, and finally, by a series of intermittent reversionary movements, once more to an approximation to its former course down the eastern margin of the delta. Throughout the study the delta is considered as a physical unit, and equal attention is given to the Mexican and United States portions.

The origin and physical characteristics of the detrital load carried by the river and the manner of its delivery, dispersal, and deposition within the deltaic area form the central theme of the third part of the volume. Attention is here also paid to the effect of vegetation and evaporation and the great tides and tidal currents of the head of the Gulf of California on these phenomena.

The volume contains numerous illustrations, including air photographs, a classified bibliography, and an insert map in color.

Distribution of Title Page, Contents, and Index of Volume 25 of the Geographical Review. The title page, table of contents, and index for Volume 25 of the *Geographical Review* (1935), which is issued separately, will shortly be ready for distribution. Copies are sent to all institutions exchanging publications with the Society and to individuals who request that their names be put on a list for this purpose.

GEOGRAPHICAL RECORD

NORTH AMERICA

Local Government Areas. It is a simple postulate of political geography that the size of an area that can be effectively operated as a political unit is dependent on the available transportation facilities. The railroad development of the nineteenth century made the task of organizing most of a continent into one nation an easier one than the original coördination of the thirteen states confined to one seaboard. While the areas of the several states have not been altered to meet this change, their political significance has; "states' rights" gradually gave way. The changes of this century in long-distance transportation have so far had but minor effects; the great change is in local transportation, thanks to motor vehicles and good roads. Business organizations and consumers alike have accepted the advantages of increased radius of action which these afford, but governmental functions show the typical "social lag." The county, township, and school-district systems, developed in the days of horse and wagon on dirt roads, remain but little changed in the day of the automobile and hard-surfaced highway (see, for example, "New England's Prospect: 1933," *Amer. Geogr. Soc. Special Publ. No. 16*, 1933, pp. 415–430 and 461–470).

While it is common knowledge that we have a great number and variety of local governmental units in the United States, there has been no reliable estimate, even, of their actual number. A two years' study, aided by the Social Science Research Council and the University of Minnesota, under the direction of Professor William Anderson, has assembled and appraised these facts for the whole country (The Units of Government in the United States, *Public Admin. Service Publ. No. 42*, Chicago, 1934). Of areal units with separate governmental organization and powers the United States has more than 175,000, or more than one for each thousand of population—in six states as high as one for less than 250 people. The number of different units now operating and the number suggested in this study as "a rationalized scheme" are given in the following table:

Type of Unit	Present Number	Recommended
Counties	3,053	2,350
Incorporated places	16,366	15,000
Townships	20,262	None
School districts	127,108	None
Other units	8,580	500
Total	175,369	17,850

The chief change suggested is the elimination of school districts, the schools to be administered as part of the other units—counties, or larger incorporated places (together with the more populous "towns," really townships, of New England, which are included with the incorporated places in the last column). Township lines may be retained for various purposes, but their governmental functions should be taken over by the larger units.

County consolidation, according to this plan, would be necessary not only in the sparsely populated Western states—where the units are already large in area—but also throughout the West Central states and in most of the South, where counties are well below the average in area as well as in population. Studies in Minnesota indicate a desirable minimum county of thirty to thirty-five thousand population, but it is recognized that this might vary in other areas.

In at least one state, Oregon, the problem has been studied in detail, with significant recommendations. The *Commonwealth Review* (University of Oregon) has published a series of studies recommending consolidation of the 36 counties of that state into a much smaller number. W. D. Smith and A. L. Lomax (Realignment of Oregon Counties, *Commonwealth Rev.*, Vol. 15, 1933–1934, pp. 129–143; Vol. 16, 1934–1935, pp. 7–18) suggest a scheme of eight or nine counties based on physiographic divisions. Dr. Stephen B. Jones, geographer at the Oregon Normal School, suggests a different basis, in the light of intra-state divisions now used by various governmental and private agencies (Intra-State Boundaries in Oregon, *Commonwealth Rev.*, Vol. 16, 1934–1935, pp. 105–126). Eight maps show the intra-state boundaries employed by six departments of the state government, one department of the federal government, and one commercial agency (wholesale druggists). Although these vary in the number of divisions (from 4 to 17) and in the particular boundaries, some of the latter are the same on many or even all of the maps. On most of them, conformity to physiographic regions is sacrificed to coherence of transportation. However, at least the middle part of the Cascade divide appears consistently; the southernmost county east of that divide (Klamath) is in every case separated from the county on its north (Deschutes), but is sometimes connected with the area west of the Cascades; the counties of the Deschutes River valley are generally joined; and in other ways the divisions are in harmony with the highway pattern. Eight agencies, six of them departments of the state government, employ different schemes of intra-state division with great variations in the number of divisions used; some other agencies treat the state as a unit; and still others operate through the existing 36 counties. These facts are considered a strong argument for the abolition of counties and the assumption of county functions by the state through varying subdivisions.

RICHARD HARTSHORNE

New Evidence on the Stability of Sea Level on the New England Coast. Large Indian shell heaps at Damariscotta, Me., have been examined and mapped in detail with a view to shedding light on the stability of sea level along the Maine coast (R. P. Goldthwait: The Damariscotta Shell Heaps and Coastal Stability, *Amer. Journ. of Sci.*, Ser. 5, Vol. 30, 1935, pp. 1–13). These heaps, unique because they are composed almost entirely of oyster shells, cover several acres of ground. Their bottom lies in close relation to present sea level, but in no place is it found to extend below the present high-water mark. Those areas of shell heaps lying on gentle slopes adjacent to salt marsh are of particular importance to the problem. Trenches dug across the inner end of the salt marsh show shell heaps everywhere overlying marsh material. "If there had been even a half foot rise in high tide level across this gentle slope (four degrees) the marsh grasses which grow to extreme tide limit would have formed a distinct layer over the shells." All direct evidence points to stability of sea level during and since the accumulation of the shells.

The antiquity of the heaps—the period during and since which sea level has apparently remained stable—is a different problem to solve. There are many variables to consider. If it is assumed that the shells were accumulated merely because of convenience to oyster beds, a start can be made. Convenience seems to be "the only evident reason for such localization." The number of oysters represented by the heaps can be roughly estimated, their average life span determined. It is assumed that the rocky estuary bottom adjacent to the heaps is the site of the former natural oyster beds from which the shells were obtained. Its area can be determined, the number of oysters capable of growing there estimated. Relation between the number of growing oysters and the number of shells of average size in the heaps will allow a rough estimate of time available for accumulation of the heaps. Furthermore, the heaps had been abandoned 300 years ago, when white settlers first arrived.

It would not seem necessary for the author to restrict available oyster beds to that area lying below low-tide level (the five-foot-depth contour), since even in cold waters natural oyster beds are known to thrive as "bars" uncovered daily at low water. His estimate of three oysters to a square foot seems assuredly conservative. A favorable oyster set of one year may account for a greatly increased number of edible oysters in three or four years. Any factors that would tend to increase the available oyster supply would necessarily tend to decrease the estimated number of years for heap accumulation. In order to allow for the uncertain factors, the author has given maximum and minimum estimates. His minimum period for heap accumulation, 500 years, is almost 300 per cent less than his liberal estimate. In spite of such necessarily variable estimates, the antiquity of the heaps appears certain. His conservative estimate of age is, in all, about 950 years, and evidence points to a stable sea level during that time.

The Fiord Coast of British Columbia. The geomorphic development of the general features of the coast of British Columbia has for the first time been described as a single unit in a recent study by M. A. Peacock (Fiord-Land of British Columbia, *Bull. Geol. Soc. of America*, Vol. 46, 1935, pp. 633–696). In view of the fact that detailed studies fall far short of covering the region, debatable subjects are clearly outlined and pure description has been separated from what is considered to be reasonable explanation. It is believed that the physical development of the coast line has been influenced by a combination of earth movements, stream erosion, and glacial excavation. If we disregard the details of development previous to the Pleistocene, the present major physical features may be ascribed largely to powerful ice erosion and recent stream erosion in conjunction with a net subsidence of 1000 feet of a rejuvenated, deeply dissected mountain belt. In determining the approximate amount of crustal warping in glacial and postglacial time advantage was taken of the presence of deep submarine channels extending outward on the continental platform. Accepting the hypothesis that these channels, now reaching 1000 feet below sea level, were carved by subaerial streams and taking into consideration the presence of high-level beach gravels at 600 feet, Peacock concludes that the total subsidence amounted to some 1600 feet. The study forms an interesting example of the combination of the tectonic and glacial theories in explaining the origin of fiords.

EUROPE

The Growth of Europe's Population and an Estimate for 1936. Soviet Russia is adding to its population every year almost as many individuals as are all the western European nations put together (Fig. 1). The annual increment of the 26 western nations of Europe between 1920 and 1932 averaged 3,196,000 individuals, that of Soviet Russia 3,076,000.

In estimating the population of the European countries for January 1, 1936 (Fig. 2), use was made of the totals given in the two latest censuses of each country. From these two totals annual increments have been derived. The reader will perceive their interesting political and military implications. Poland is adding more to its population annually than any other country in western Europe, though four of them still greatly outnumber Poland. Great Britain and Northern Ireland are close to Poland. In its annual increase Germany is now as far behind the United Kingdom as it is ahead of Italy. Before the war Germany, even without Alsace and Lorraine, had more than twice its present annual increment of population. Poland, with about half the population of Germany, has a larger increment of population by a hundred thousand. Great Britain, with but two-thirds of Germany's present population, outgrows Germany by 27,000 a year. The Netherlands, whose total population numbers are nearly identical with those of Belgium, greatly exceeds Belgium in

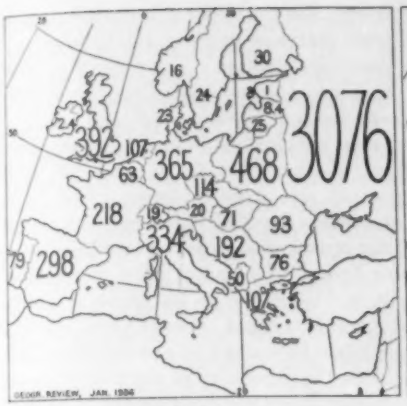

FIG. 1

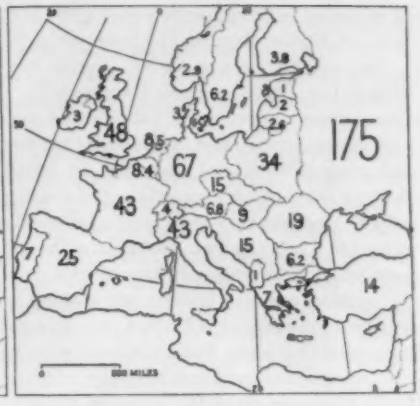

FIG. 2

FIG. 1—Estimated average annual increment of population between 1920 and 1932 in thousands.
FIG. 2—Estimated population as of January 1, 1936, in millions.

annual growth. Denmark, with six-tenths as many people as Sweden, has nine-tenths as great an annual increment of population.

Before the war France was the notorious example of a population in stagnation. About 1905 France was the eighth European nation in terms of annual additions to the population. It is now the sixth, and the yearly crop of French is 218,000, whereas 20 years ago it was 72,000. Of course, Alsace and Lorraine are now part of France, and their birth rate is higher than that of most of the rest of the republic. The increment of these two provinces for 1925–1930 was 1 per cent and that of France 0.53 per cent; but that added only 17,000 to the French increment, a small part of the whole. Germany has fallen from second place to fourth, and its increment dropped from a prewar 761,000 (without counting Alsace-Lorraine) to a present 365,000. Italy, setting out with avowed intention of increasing its population, has raised its increment from 220,000 in 1905 to 334,000 in 1923 but drops back a place in rank to make room for the new nation of Poland.

The causes of all these changes are complex but interesting. Birth rates in general trend downward, but emigration is greatly checked by American action. The French increase is influenced by immigration of workers invited in.

MARK JEFFERSON

Is Nationalism Promoting Erosion? Ultranationalism, with the high tariffs, embargoes, and subsidies that are intended to promote self-sufficiency, may ultimately produce decidedly opposite results. The increased home production of grains and sugar beets and the decreased importation of wheat, flour, and sugar, although perhaps justifiable with the prospects of an impending war, may not be good politics or economics when viewed from a long-time basis.

Great Britain has long been noted for the quality of its pasture and the extent of its grasslands and meadows, but in the present wave of nationalism that is sweeping the world the British government has in a measure yielded to popular demand for self-sufficiency and is promoting the production of larger acreages of grains, sugar beets, potatoes, and other foodstuffs. Uplands that have not been plowed for scores of years are being put into crop. The shallow depth of the soil profile and the generally sloping surface make it not only probable but almost certain that the productive capacity of many of these soils will be materially reduced by erosion. The current effect of erosion is evidenced by the elevation of the land on each side

of stone walls or hedgerows that cross the slopes. On the upper side the soil surface is much higher than on the lower side, in some places as much as two to four feet.

The upland soils of Great Britain are relatively shallow. The profiles studied during the Post-Congress Excursion of the Third International Congress of Soil Science (see above, p. 140) showed an average depth of about 25 inches in England and Wales, where most of the soils that were seen were formed from residual material and some from glacial deposits. In Scotland, where most of the soils studied were derived from glacial materials, the average depth was about 40 inches. The chalk soils of England that were studied showed an average depth of 10 inches and extreme ranges of 7 to 17 inches. Erosion, although not conspicuous, is active on all these upland soils. One profile on the Harper Adams Agricultural College Farm in northern Shropshire was on a moderately sloping hillside. When the pit for profile exposure was being excavated, a Roman coin was uncovered at a depth of about 5 feet. It was suggested that some Roman interested in soils might have dug a hole at that place, but the topographic evidence strongly indicated that the deposition of material removed by slow erosion from the adjacent slightly steeper fields had built up the hillside at this particular place to the indicated depth. Evidence of erosion from a field of cabbages above the pit was distinct and definite, though the evidence of deposition in the vicinity of the pit was not so obvious.

All the ruins of Roman occupation show evidence of erosion and deposition, and near these ruins there are indications that some of the slopes now in grass had been tilled at much earlier times. Is it not possible that the countrymen of a few centuries ago showed wisdom in withdrawing these uplands from cultivation and in preventing their destruction by erosion by putting them into grass? Or were they at that time so badly eroded that crop production no longer proved profitable and the reversion to grass was forced? In England we were assured that because of the gentle rainfall there is very little erosion from cultivated lands, but in every field critical observation showed at least minor evidence of erosion from the steeper slopes and deposition on slopes less steep. And in the descriptions of the soils of Wales presented at the Congress considerable space was devoted to discussion of profiles that have been truncated by erosion in the past.

Throughout much of England and Scotland there are extensive pastures and some hayfields on the bottom lands where deposition instead of erosion is taking place. With the demonstrated higher productivity of these lowlands and the obvious dangers of destructive erosion that would follow the tilling of the sloping uplands, a directed agriculture, planned for the maintenance of crop production throughout the entire country and for the preservation and most effective utilization of the unreplaceable soil asset, would call for a utilization of the lowlands for crops and the maintenance on the uplands of a grass cover that will provide feed for animals and protection from erosion. The self-sustaining program of nationalism could well note these evidences of actual or potential soil destruction and plan the agricultural activities on a soil-preserving basis. Self-interest alone would dictate such a program.

CHARLES F. SHAW

AFRICA

A Note on Ethiopia. Ethiopia comprises two plateaus almost completely surrounded by lowlands and separated from each other by a deep structural trench or graben. The northern and larger plateau is generally known as the Abyssinian highland. Its north half is inhabited by Abyssinians and forms the original nucleus of the Empire of Ethiopia (Fig. 1d). Other parts of the Empire are the territories of subject peoples. The smaller plateau to the southeast, which has been called the Somalian plateau, presents a steep face to the northwest and north but falls away gradually southeastward into the plains of Ethiopian and Italian Somaliland. The graben forms a part of the great East African system of rift valleys.

Both plateaus are underlain by nearly horizontal beds of sedimentary rock resting on a crystalline foundation (Fig. 1c). The crystalline base is exposed only around the margins of the plateaus and in some of the deeper valleys. Most of the upland surface and also the floors of the graben and northeastern lowland are covered with trap and other eruptive and intrusive rocks.

The Abyssinian highland overlooks the lowlands to the east with a mighty escarpment, from whose crest the upland surface descends westward to the plains of the White Nile in a series of great steps. The east rim of the Nile watershed lies close to the escarpment. According to the maps of the Geographical Section of the British General Staff (1 : 1,000,000), no part of the divide bounding the catchment basin of the Blue Nile within the highland area lies below an altitude of 2500 meters. The altitude of Lake Tana is about 1840 meters (G. W. Grabham and R. P. Black: Report of the Mission to Lake Tana, 1920–1921, Ministry of Public Works, Egypt; Cairo, 1925, p. 13). If the contours on the General Staff map are approximately correct, this means that a dam not less than 660 meters high would have to be built in order to divert the waters of Lake Tana or of the Blue Nile out of their present watershed. (Boulder Dam is only about 226 meters high.) This would seem to make inherently improbable recent newspaper stories to the effect that only a few tons of dynamite need be exploded at a critical point to accomplish this diversion and thereby bring ruin to Egypt. Indeed, even if it were possible to cut off Lake Tana's contribution to the Nile, the effect on existing conditions in Egypt would probably not be very serious, since "the discharge of the lake corresponding to the highest levels of the flood amounts to only about one-fiftieth part of the volume entering Egypt" (*ibid.*, p. xii). The Blue Nile gets most of its water from tributaries draining the rainier regions to the south, southeast, and southwest of the lake (see Herma Plazikowski-Brauner: Die Tsana-Frage und das Eindringen der Amerikaner in Abessinien, *Zeitschr. für Geopolitik*, Vol. 7, 1930, pp. 128–135; reference on p. 130). The proposed conservation works at the outlet of Lake Tana, however, would preserve water "for release when the silt-charged flood waters" subside, and water is "urgently needed in Egypt for crops between March and June" (A. B. Thompson: The Water Problems of Abyssinia and Bordering Countries, *International Affairs*, Vol. 14, 1935, pp. 769–779; references on p. 770).

The rivers in the Abyssinian highland have carved deep, canyon-like valleys for themselves, and the interfluves are for the most part isolated from one another. The obstacles that this topography offers to an army advancing southward from a base in Eritrea, as well as other geographical difficulties in the way of modern military operations in Ethiopia, are outlined by H. Scaetta in a paper entitled "Geography, Ethiopia's Ally" (*Foreign Affairs*, Vol. 14, 1935, pp. 62–70). (For additional details see Franz Thorbecke: Das Hochland von Abessinien, *Geogr. Zeitschr.*, Vol. 39, 1933, pp. 292–302; Siegfried Passarge: Wirtschaftsmöglichkeiten im eigentlichen Abessinien, *Geogr. Wochenschr.*, Vol. 3, 1935, pp. 809–819; Erich Sander: Das Hochland von Abessinien (Habesch): Eine länderkundliche Monographie, Heidelberg, 1929.)

An accompanying map (Fig. 1a), based on a map by Passarge (*op. cit.*, p. 810), shows the natural landscapes of Ethiopia arranged in five groups. The salt steppes and dry steppes of the lowlands and graben as well as the long strips of dry steppe that penetrate the Abyssinian highland along the larger river valleys are wholly unsuited to European settlement. Much of the northeastern and eastern "steppe" is a "desert of scrub and thorn," the "Hell-Hole of Creation" according to L. M. Nesbitt in the volume of that title reviewed in the last number of this journal (*Geogr. Rev.*, Vol. 25, 1935, pp. 689–690). The dry steppes within the highlands are generally avoided by the natives owing to the prevalence of malaria and dysentery. Passarge's zones of mountain grasslands and forest and of mountain pastures with cloud forests (*Nebelwald-Hochweiden*) are still only primitively developed, but they are lands of great potential productivity. "The volcanic soils, the abundance of water,

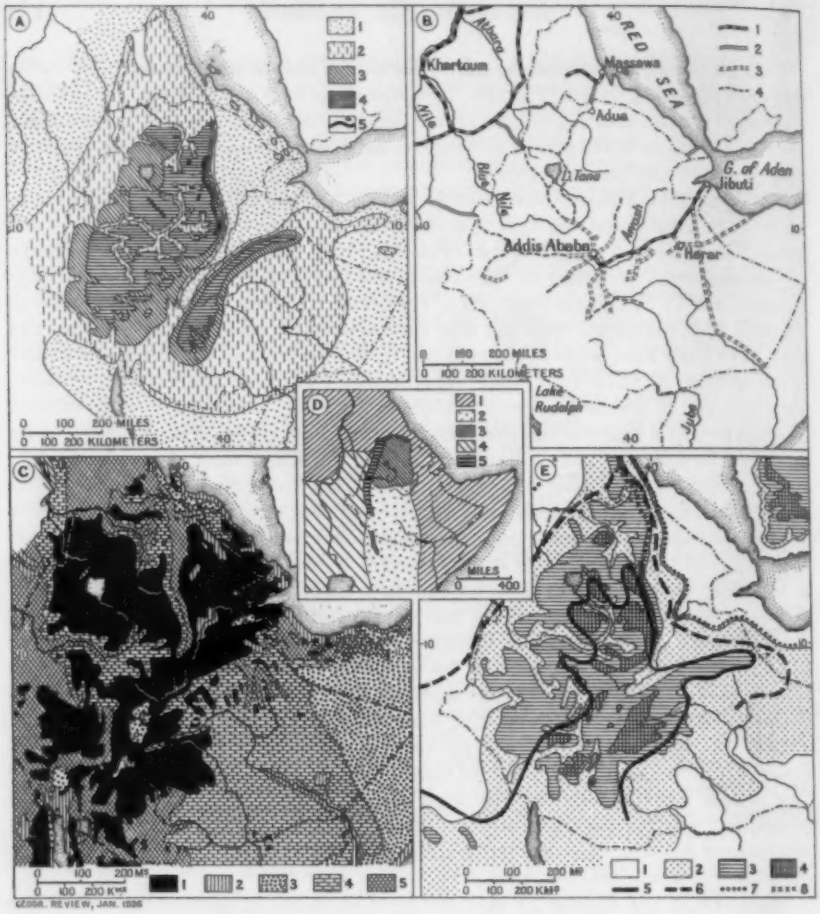

FIG. 1—Five maps of Ethiopia. *Map A*, natural regions: (1) salt steppes; (2) dry steppes; (3) mountain grasslands and forest; (4) mountain pastures and cloud forest at lower elevations, alpine meadows at higher elevations; (5) rocky summits.

Map B, modern transportation routes, 1934: (1) railroads; (2) highways; (3) completed auto trails; (4) proposed auto trails.

Map C, principal geological formations: (1) eruptive and intrusive rocks; (2) Quaternary; (3) Tertiary; (4) Mesozoic; (5) crystalline foundation.

Map D, principal racial stocks: (1) Hamitic pastoral peoples, Arabs in the Sudan; (2) Galla and other Hamitic-Negro mixed stocks; (3) Abyssinians; (4) Negroes; (5) dense population of Hamitic and Negro stocks in the valleys of the Abyssinian highland.

Map E, climate: (1 to 4) zones of mean annual temperature: (1) above 25° C. (77° F.), (2) 25°–20° C. (77°–68° F.), (3) 20°–15° C. (68°–59° F.), (4) below 15° C. (59° F.); (5 to 7) length of rainy period: (5) 200 days, (6) 150 days, (7) 50 days (limit of agriculture based exclusively on irrigation); (8) western limit of area of winter rains.

Maps A and B are based respectively on maps in Passarge's and Winkler's papers cited in the accompanying text; Map C is generalized from a map accompanying Blondel's paper cited in the text; Map D is based on a map in Siegfried Passarge: Abessinien und Italien, *Geogr. Wochenschr.*, Vol. 3, 1935, pp. 241–247, map on p. 242; Map E is based on a map in G. Selyaninov: Agroclimatical Zones of Abyssinia, Eritrea, and the Adjoining Parts of Sudan and Somaliland [in Russian], *Bull. of Applied Botany, of Genetics and Plant-Breeding* (published by the Lenin Academy of Agricultural Sciences in U.S.S.R., Leningrad), Vol. 22, No. 5, 1929–1930, pp. 489–521, map facing p. 512. Approximate scales: Maps A, and B, 1 : 310,000,000; Maps C and E, 1 : 270,000,000; Map D, 1 : 900,000,000.

and the healthful climate" (Fig. 1e) would support a large white farm population here—perhaps as many as 30 or 40 million, if Passarge's estimate may be accepted. Cotton, coffee, maize, bananas, rice, grapes, and silk could be produced at lower altitudes within these zones and wheat, barley, oats, and potatoes at somewhat higher levels. The area lies outside the tsetse-fly region and is adaptable to stock raising on a large scale as well as to field crops. The highest parts of the plateau rise to altitudes of more than 4000 meters. "Snow lies on the ground for months at a time, . . . [and] the flora [is] a high-mountain type related to the floras both of Europe and of the Cape" (Thorbecke, *op. cit.*, pp. 294 and 296).

Only in the ancient crystalline rocks are metallic ores of value likely to be found (Fig. 1c). "Gold is the most probable and most abundant of these." Platinum has been mined in small quantities. There would seem to be little hope of finding coal of good quality. There are indications of petroleum on certain islands in the Red Sea, and it may not be lacking in Ethiopia. However, F. Blondel states that petroleum is probably confined to rocks of Tertiary age, which occur only in relatively small areas within the boundaries of Ethiopia (La géologie et les ressources minérales de l'Ethiopie, de la Somalie et de l'Eritrée, *La Chronique des Mines Coloniales*, Vol. 4, 1935, pp. 306–317, with a geological map and a useful bibliography).

On Figure 1d the lines showing the "modern transportation routes of Ethiopia" as of 1934 have been taken from a map illustrating a paper by Ernst Winkler (Zur Verkehrsgeographie Abessiniens, *Geogr. Wochenschr.*, Vol. 3, 1935, pp. 431–436). There are almost no built highways in the country. Instead, the Ethiopian government is developing a system of auto-trails that may be opened up at a much lower cost than is required for the construction of roads of the conventional type. "Over large areas the . . . traprock surface facilitates the making [of these routes], for with practically no technical alterations, except at the most the removal of the vegetation cover, the surface can be made passable for motor vehicles."

Rock Paintings and Drawings in Northern Africa, 1933–1934. The past two years have witnessed an unusual output of publications dealing with graffiti and rock paintings in northern Africa. The mass of interesting drawings of animals along the banks of the Nile Valley in Nubia, carved on the Nubian-sandstone cliffs and boulders and remarked on here and there by many previous investigators, have at last found a systematic and understanding chronicler in J. H. Dunbar (Some Nubian Rock Pictures, *Sudan Notes and Records*, Vol. 17, 1934, pp. 139–167). His fascinating and beautifully illustrated paper is the outstanding contribution to the study of graffiti in recent years. Dunbar has examined thousands of examples in Nubia. These he marshals into three groups, characterized respectively by a predominance of game animals, of cattle, and of boats, and he considers them to be the work of three successive waves of inhabitants, occupied mainly in hunting, farming, and trading. The earliest drawings are always those of elephants, after which come giraffes, antelopes, and ostriches. The cattle are next in order of date, and most of the boats are latest of all, though the earliest boats may antedate the cattle. The possibilities of dating the boats by comparison with drawings on pottery and other objects of known date are discussed by G. W. Murray and O. H. Myers, who conclude that some examples near Aswan are predynastic (Some Pre-Dynastic Rock-Drawings, *Journ. Egyptian Archaeol.*, Vol. 19, 1933, pp. 129–132). Dunbar holds that all the evidence favors the idea arrived at by the present writer in a recent publication that the oldest group, especially the elephants, are Upper Paleolithic—perhaps as early as Middle Aurignacian, since the earliest predynastic is known to be about coeval with European Magdalenian. Like the writer also, he considers the early elephants and giraffes as comparable in style and date with those in the oasis of Uweinat (K. S. Sandford and W. J. Arkell: Paleolithic Man and the Nile Valley in Nubia and Upper Egypt, *Univ. of Chicago Oriental Inst. Publs.*, Vol. 17, 1933, Chapter

8, especially pp. 64, 69, and 70. My reviewer, H. J. Fleure, in the January, 1935, number of this journal, is mistaken in his implication that I assert that this group occurs at Uweinat alone).

The known Uweinat graffiti, discovered by Hassenein Bey and made famous by Breuil and Newbold, were augmented in 1933 by the Italians' discovery of about a dozen little caves near the spring 'Ain Daua in the same massif, the insides of which are covered with paintings. The pictures are in four colors and represent cattle and other domesticated animals and human figures, with *Bos africanus* of the Egyptian Old Kingdom in evidence. They have been copied and lavishly published by Lodovico di Caporiacco and Paolo Graziosi (Le pitture rupestri di Àin Dòua (el-Auenàt), *Centro di Studi Coloniali*, 1934). Accounts are also given by Enrico De Agostini (El-Auenàt chiave del deserto libico, *Riv. delle Colonie Italiane*, Vol. 8, 1934, pp. 807–823) and in English by R. A. Bermann (Historic Problems of the Libyan Desert (*Geogr. Journ.*, Vol. 83, 1934, pp. 456–470). Near by was found a double burial, the two bodies superimposed and in identical attitudes, with two urns made of pottery like that of ancient Nubia and protodynastic Egypt (see Agostini, *op. cit.*).

Far to the southeast in Abyssinia, at Sourré in the Harar district near the Somaliland frontier, closely comparable paintings have been described by H. Breuil (Peintures rupestres préhistoriques du Harrar (Abyssinie), *L'Anthropologie*, Vol. 44, 1934, pp. 473–483). They are likewise naturalistic and represent the animals in yellow, black, red, and brown. Breuil believes that this discovery testifies to an ancient civilization once extending from Abyssinia to and beyond the Libyan Desert. He contrasts with these paintings Abyssinian schematic animals found at Dire Dawa.

In central North Africa much work has been done in Fezzan and Tripolitania (Italian Libya) and the neighboring French territories to the west. Graziosi describes at Wadi Zigza near Brach, south of the Hamada el Homra, naturalistic giraffes and an elephant like those at Uweinat and comparable with others already known in the Ahaggar district in southern Algeria, four or five hundred miles to the west (Recherches préhistoriques au Fezzan et dans la Tripolitaine du Nord, *L'Anthropologie*, Vol. 44, 1934, pp. 33–43). At el Gheriat in northern Tripolitania Graziosi found large ostriches of a style similar to that of the buffalo pictures of Algeria. A beautifully illustrated account of the Fezzan drawings is given by Emilio Scarin (Distribuzione topografica delle incisioni rupestri nel Fezzan, *Le Vie d'Italia e del Mondo*, Vol. 2, 1934, pp. 1429–1448). He explains that some antedate the introduction of the camel, while those among which the camel is represented may be of any date down to the present day. Some of the camels are drawn on Roman ruins. Numerous tifinagh inscriptions have also been copied.

A few hundred miles west of this region, in the Tassili plateau, just over the French border, were found the paintings and engravings discussed by E. F. Gautier in his interesting article on "The Ancestors of the Tuaregs" in the January number of this *Review*. In 1935 similar paintings were discovered on the Tefedest uplands of the Ahaggar district by a party of French mountain climbers under the leadership of Captain Coche (*L'Illustration*, November 30, 1935, pp. 400–405).

From the Tefedest uplands it is a step of more than a thousand miles westward across the Sahara to the Adrar district in Mauritania, not far from the Atlantic coast, where graffiti have been discovered by T. Monod (see "Recherches scientifiques au Sahara occidental," *L'Afrique Française*, Vol. 44, 1934, pp. 561–562). As in the northern and central Sahara, there are here several superimposed groups. The modern and Arabic inscriptions overlie others in the tifinagh characters of the Tuaregs with horse and camel pictures; below all and obviously earliest are deeply patinated drawings antedating the camel. Monod found ancient burials surmounted by steles bearing drawings of the oldest group. It will be interesting to see if the burials when excavated throw any light on the dating of the graffiti. Enormous numbers of Chellean *coups de poing* were found on the surface.

Far to the southeast of this district, in the region of the upper Senegal, Griaule describes modern paintings in the mountains of Kita and correlates them with current ritual ceremonies, such as commemoration of the dead and circumcision (Rites relatifs aux peintures rupestres dans le Soudan français, *Compte Rendu Sommaire des Séances de la Soc. de Biogéogr.*, Vol. 11, 1934, pp. 65–68). Farther east, in the basin of the upper Niger, Mourgues records numerous recent ocher paintings, which are still being added to (Gravures rupestres chez les touareg nigériens, *Renseign. Colon.* (*Suppl. à l'Afrique Française*), 1934, pp. 145–148). In addition there are some rock engravings of horses with and without riders, and other objects, fairly well patinated and apparently "assez anciennes." Not far away is a cemetery whose origin is unknown to the natives. The tombs are marked by upright stones arranged in concentric circles in a way foreign to all the existing tribes of the region. The guide believed they belonged to the forgotten makers of the earliest graffiti.

Although this note deals primarily with northern Africa, the reader's attention is called to the comprehensive and superbly illustrated monograph of M. Wilman, "The Rock-Engravings of Griqualand West & Bechuanaland, South Africa" (Cambridge, 1933), which includes a map showing the location of engraving localities in the region of the Orange River and its tributaries.

W. J. ARKELL

ASIA

The Industrialization of Asia. Although the dislocation of world trade resulting from the growing industrialization of Asia is common knowledge, how far this industrialization will proceed and what its future effects will be are matters of conjecture. In terms of area, industrialization is not now far advanced. Japan, China, and India are the only countries important in world trade. Nationalism, however, has caused small but interesting beginnings in other parts of Asia. In Persia, where modern industry may be said to date from the accession of the present shah in 1925, local industry has been aided by the foreign-trade monopoly of the government and has made real progress. Violet Conolly, who reports on a personal survey of Persian industry in the *Journal of the Royal Central Asian Society* (Vol. 22, 1935, pp. 454–463), states that there are now about 30,000 spindles distributed in well equipped factories. In Turkey a Five-Year Plan of industrial development has been adopted. It is expected that 231,900 spindles will be in operation there in 1937, or more than twice as many as in 1933 (101,000) (Gerhart Bartsch: Die Industrialisierung der Türkei, *Geogr. Wochenschr.*, Vol. 3, 1935, pp. 665–672; reference on p. 669). Even Afghanistan has factories producing cloth, soap, sugar, and shawls (C. F. Strickland: The Economic Development of Afghanistan, *Contemporary Rev.*, Vol. 143, 1933, pp. 714–722).

The history of industry has been different in each of the three chief industrial nations of Asia. In Japan, where manufacturing has made its greatest strides, the government has put its power and resources into the creation of a modern industrial system (see papers by J. E. Orchard cited in footnote on page 1 above). An early and effective start enabled Japan to gain a virtual monopoly over Asiatic markets during the World War. In all this development textiles have played a leading part (A. F. Barker: The Evolution of the Industrial System in the Far East, *Journ. Royal Soc. of Arts*, Vol. 83, 1935, pp. 878–894; Albert Kolb: Die Industrialisierung aussereuropäischer Gebiete, *Geogr. Zeitschr.*, Vol. 41, 1935, pp. 264–278).

In India, where there was no early government aid and where the size and decentralization of the country were real handicaps, modern industry has had a different history. During the World War India's trade fell off because the resources of plant and money needed to take advantage of the situation were lacking. At that time Japan obtained her footing in the Indian markets. Industry in India is still characterized by excessive localization (P. S. Lokanathan: Localisation of Industry in India, *Journ. Madras Geogr. Assn.*, Vol. 7, 1932–1933, pp. 16–35).

In China modern manufacturing began to develop later than in Japan or India and is still confined to a narrower range of products. That China is attaining to a degree of industrialization is shown in Professor Orchard's article on Shanghai in this number of the *Review* and also by such a publication as the volume on Kiangsu, the first of a series of industrial handbooks compiled by the Chinese Bureau of Foreign Trade of the Ministry of Industry. Internal industrial development should be greatly aided by the growth of China's system of transportation and communication (Julean Arnold: New Transportation for China, *Asia*, Vol. 34, 1934, pp. 664–671; "A Year's Progress in Transportation and Communication Services," *Chinese Econ. Journ.*, Vol. 15, 1934, pp. 44–66, reprinted in *Far Eastern Rev.*, Vol. 30, 1934, pp. 417–422). "Man-Power in China, I," by Dorothy J. Orchard (*Political Sci. Quart.*, Vol. 50, 1935, pp. 561–583), deals with one of China's "two outstanding resources for industrialization."

The nature of the industrial development of the Far East has been the subject of discussion at several conferences of the Institute of Pacific Relations. The Conference of 1929 devoted two round-table discussions to this problem (see J. B. Condliffe, edit.: Problems of the Pacific, 1929, *Proc. 3rd Conference Inst. of Pacific Relations, Japan, 1929*, Chicago, 1930, pp. 3–35 and 65–83). In preparation for the Pacific Relations Conference to be held in 1936 the Royal Institute of International Affairs has made an extensive study of the situation (see "Eastern Industrialization and Its Effect on the West, With Special Reference to Great Britain and Japan," by G. E. Hubbard, assisted by Denzil Baring, with a Conclusion by T. E. Gregory, London, 1935). Mr. Hubbard gives a summary discussion of this problem and touches on the labor questions involved in his paper "The Industrialization of Asia" (*Journ. Royal Central Asian Soc.*, Vol. 22, 1935, pp. 345–364). Other points of view are contained in an article by L. Ledermann (L'essor de l'industrialisation au Japon, *Rev. Écon. Internatle.*, 27th Year, Vol. 1, 1935, pp. 457–487) and in one by J. F. Halkema-Kohl (Die Verschiebung der Wirtschaftskräfte im Fernen Osten, *Weltwirtsch. Archiv*, Vol. 40, 1934, pp. 486–523).

MARGARET WARTHIN

Some Recent Studies of the Climate and Geography of Syria and Palestine. The French mandatory government in Syria has taken an active interest in encouraging studies of this region. One of its early steps was the establishment of a meteorological service under the direction of the Jesuit Observatory of Ksara. Father Combier has brought together in a preliminary report the available material gathered by his stations and those of the army aviation service (C. Combier: La climatologie de la Syrie et du Liban, *Rev. de Géogr. Physique et de Géol. Dynamique*, Vol. 6, 1933, pp. 319–346). This study presents the best climatic maps of the region that the reviewer has yet seen, among them a particularly valuable map of climatic regions.

Following the example of Professor Emmanuel de Martonne, Combier divides the climates of Syria into five types: desertic, three types of Mediterranean, and subdesertic. (1) The desertic climate (Saharan type) is bounded on the west by the crest of the Jebel ed Druz and the eastern foot of the Anti-Lebanon Mountains; its north edge then swings east in a long curve to the Jebel Sinjar. This climate is characterized by variable precipitation always less than 250 millimeters a year, an annual temperature range of more than 25° C., and a diurnal range frequently as great as 25° or 30°. The mean summer maxima are always above 40°, and frost is frequent in the winter. The Mediterranean climate is bounded on the east by the Anti-Lebanons, the right bank of the Orontes River, and the valley of the Afrin Su. Its three types are: (2) a temperate type with a short cold season, prevailing over a zone that coincides with the mountains (Lebanon, Anti-Lebanon, and Ansariye); (3) a Hellenic type, with greater temperature ranges and a lower relative humidity, prevailing farther east over an area including El Beqa' (Coele Syria); and (4) a

maritime type along the coast. These three Mediterranean types all have an annual rainfall of more than 500 millimeters and an annual temperature range of 14° to 19°. (5) The Syrian subdesertic type, a modification of the Mediterranean climates, includes the area between the desert and the Mediterranean regions. Precipitation ranges usually between 250 and 500 millimeters, the annual temperature range is more than 20°, and the diurnal range is occasionally greater. This zone includes Der'a, Damascus, Homs, Hama, and Aleppo.

In one of the volumes of the collection "Études Bibliques" Father Abel describes the physical background of the Bible (F.-M. Abel: Géographie de la Palestine, Vol. 1, Géographie physique et historique, J. Gabalda, Paris, 1933). The section on physical geography contains a detailed treatment of the geology and relief, climate, hydrology, mineralogy, flora, and fauna of Palestine, with occasional references to Syria. The chapter on climate is devoted to a systematic discussion of the meteorological elements, but with no attempt to synthesize the materials into climatic regions. Quotations are given from ancient sources regarding the weather and climate in early times. On this basis the author concludes that there has been no climatic change in Palestine within historical times. The scarcity of water resources in Palestine is illustrated by the number of springs to 100 square kilometers: northern Palestine has 9, Samaria 7 to 8, and Judea 2 to 3.

Abel disavows any attempt to treat of adjustment of groups to their environment: by historical geography he means "the history of the elements of physical geography," and his discussion of these elements simmers down primarily to an identification of the names applied to them by different peoples at various periods of history. Consequently, the historical part of his book will be chiefly of use to students of the Bible and to historians, though occasional bits of information of considerable interest to the geographer are introduced, as, for example, a discussion of the forest history of the Lebanon Mountains. From about 2850 to 1350 B.C. Egypt got its supply of resinous woods from this source. About 1100 B.C. the Assyrians began to use the Lebanon forests too; shortly before 700 Sargon made especially heavy demands on them. At the time of Solomon and his successors, Tyre and Sidon were the ports shipping lumber to Palestine. Alexander got the timber necessary for his siege of Tyre in the Lebanon. At that time people thought the forests inexhaustible. The fleet with which Pompey crushed the Cilician pirates was built with Lebanese timber. Under the emperor Hadrian the state reserved the pine, fir, cypress, and cedar for the sole use of the navy; forest reserves were set up in the mountains behind Beirut and Batrun in order to assure an adequate supply.

In an excellent article on irrigation in Palestine J. Gottmann approaches the subject from the viewpoint of economic geography (L'irrigation en Palestine, *Ann. de Géogr.*, Vol. 44, 1935, pp. 143–161). Five maps show the distribution of precipitation, agricultural regions, Jewish landownership in 1934, irrigated lands in 1933, and the location of citriculture.

The economy of Palestine has been greatly changed as a result of fifty years of Jewish colonization. The increase in population density has forced a more intensive utilization of the soil through irrigation. Jewish-owned land has grown from nothing in about 1875 to a total of more than 120,000 hectares in 1933. Irrigation is most developed in regions of Jewish ownership, especially in the coastal plain, the plain of Jezreel, and the Jordan Valley. It is a result of private initiative and so lacks planning, wastes water, and needs coördination.

Citrus fruits constitute the leading irrigated crop of Palestine, and citriculture is the chief industry. In 1927 it was estimated to cover 4000 hectares; in 1932 estimates ranged from 16,500 to 20,000 hectares. In 1932 citrus fruits furnished 74 per cent of the total value of exports. The Jews dominate the industry and have organized coöperatives to handle their marketing with the most modern methods. The industry is primarily an export one. Great Britain takes 60–75 per cent of the exports.

Irrigation has also permitted the unusual development of forage crops and of a milk industry, which centers in the upper Jordan Valley, in the plain of Jezreel, and around Jaffa. North-European cattle are used, often crossed with the Damascus and Beirut breeds. In 1932 the total milk production was 6,000,000 liters; this was not enough to satisfy the demand. Other irrigated cultures include vegetables for the home market, bananas, which have just lost their Egyptian market through a higher import tariff, and a variety of other fruits. Date culture could be expanded considerably; there are now only a few thousand date palms south of Gaza, and the country is a heavy importer of dates. According to present knowledge, future rural colonization and expansion of irrigation can take place only toward the south and the east, into the more arid regions.

J. ALLEN TOWER

WORLD AS A WHOLE AND LARGER PARTS

The Suez Canal. The few cultural features associated with the Suez Canal lie in an arid waste without seeming to affect the appearance or utilization of the contiguous buff-colored dunes and plains of desert sand. A road and a railroad follow the west or African side of the canal connecting the urban unit of Port Said and Port Fuad at the Mediterranean entrance with Port Tewfik and the adjacent city of Suez at the south terminus on the Gulf of Suez. From Ismailia, near the midway point, a railroad leads westward to the economic heart of Egypt, the irrigated Nile Valley and the broad, fertile delta. Parallel to this railroad is a small canal, which brings fresh water from the Nile to the cities of the canal zone. Some of the surplus water is used for irrigation, and the oases, which may be seen from passing ships, are remembered vividly in their contrast with the desert. Small boats ply upon this waterway, but at present "the Ismailia Canal is little used for any sort of transportation except the occasional shipment of coal from the Suez Canal" (E. M. Wilson: Zagazig: A Cotton Market, *Geogr. Rev.*, Vol. 24, 1934, pp. 566–575; reference on p. 572).

Port Said has grown in almost direct proportion to the increase in business of the waterway itself. In 1883 its population was 17,000; by 1917 this had risen to 75,192; and in 1927 it was reported as 104,603. The growth and prosperity of Port Said are based on certain functions connected with the canal, one of the most important of these being services to passing ships. Port Said is also a refueling port. Two kinds of fuel are transshipped here: coal, most of which comes from England (772,000 tons out of a total of 866,489 in 1930) and oil, which was supplied in 1930 in the following amounts: Persia 185,345 tons, Russia 111,087 tons, Rumania 102,686 tons, and Venezuela 47,524 tons (A. Solletty: Port-Saïd, *Ann. de Géogr.*, Vol. 43, 1934, pp. 510–525, especially pp. 521–525).

It was once thought that Port Said might eventually become a serious rival of Alexandria, but this has not occurred. In 1933 Alexandria handled more than 80 per cent of Egypt's foreign trade, and Port Said came second with only 8.4 per cent (*ibid.*, p. 516). This again indicates the isolation of the canal zone from the economic heart of Egypt. The cost of service by rail or by the Ismailia Canal and Lake Manzala route makes it more advantageous to float bulky agricultural raw material for export down the river to Alexandria and to return imports by the same route. Furthermore, Alexandria is established as the banking and marketing center of Egypt; it has good facilities for handling the produce; and it is a port of call for boats plying only on the Mediterranean as well as for a large number of the liners traversing the Suez Canal.

During the period from 1925 to 1930, 33,981 ships passed through the canal. The yearly average was 5663.5 ships and the daily average 15.51 (C. W. Hallberg: The Suez Canal, *Columbia Univ. Studies in Hist., Econ., and Public Law, No. 348*,

New York, 1931, pp. 379–380). The number going from south to north exceeds the number going in the opposite direction. In 1933 the proportion was 2852 to 2571 (Suez and Panama Canal Traffic in 1933, *Board of Trade Journ.*, London, March, 1934, p. 445). Around-the-world ships account for much of this difference, for they generally go in a westerly direction. Whereas the share of the United States in the Suez Canal traffic has always been small, that of Great Britain has consistently been above 50 per cent of the total.

In view of the British political and financial predominance of interest, a rather anomalous condition exists. Because the block of stock bought by Disraeli in 1875 from the Khedive of Egypt carried with it decidedly restricted voting rights, the control of the company operating the canal has remained in French hands. Business is conducted in the French language, most of the administrators and employees are French, and, although the Suez Canal company is incorporated in Egypt, its headquarters are in Paris (Sir Arnold T. Wilson: The Suez Canal: Its Past, Present, and Future, London, 1933).

The Panama Canal cost two and a half times as much to build as the Suez Canal, and its annual cost of upkeep is almost in proportion. With about the same amount of tonnage passing through, the Panama Canal pays its way; the Suez Canal dues are 40 per cent higher for a ton of shipping and 44 per cent higher for a ton of cargo. The trade for which these canals compete is that which flows between the North Atlantic countries on the one hand and northeastern Asia, New Zealand, eastern Australia, and the west coasts of North and South America on the other. In 1933 there was an increase in the traffic through each canal over that of 1932, amounting to 8 per cent for the Suez Canal and 12 per cent for the Panama Canal (*Board of Trade Journ.*, March, 1934, p. 444). To a slight extent this seems to bear out the contention that there is a real tendency to divert traffic from the Suez to the Panama route and in part to benefit the United States trade in the Orient at the expense of European countries. Nevertheless, there is not enough evidence as yet to make any conclusive statement concerning the tendency of high rates to divert traffic from the Suez Canal.

W. M. HANLEY

THE OCEANS

The Sargasso Sea. Our present knowledge of the oceanic region known as the Sargasso Sea is reviewed by Louis Germain in "La mer des Sargasses" (*Bull. l'Inst. Océanogr. No. 671*, Monaco, 1935). This unique region, characterized by the widespread presence of *Sargassum*, or seaweed, and further distinguished by the exceptionally high salinity, high temperature, and great transparency of its water, was first definitely brought to notice by Columbus, who crossed it on his historic voyage to the New World. There are, however, references by ancient and medieval writers to a region in the Atlantic covered with "grasses," and Germain accepts these as indicating a knowledge of the Sargasso Sea before the time of Columbus.

Since the seaweed floats on the surface of the water, it drifts with the wind. Hence, no definite boundaries can be set for the Sargasso Sea. If it is limited to the region in which seaweed occurs frequently, its outer limits may be fixed approximately by the 20th and 40th parallels of north latitude and the 35th and 75th meridians of west longitude. Within these limits the Sargasso Sea has a roughly oval outline with a hump north of Bermuda and occupies an area of more than two million square miles.

The greater part of the floating seaweed of the Sargasso Sea is made up of three closely related species of *Sargassum*. The earlier theory of the origin of this seaweed held that it came from the shores of the West Indies and the Bahamas, whence it was carried into the Sargasso Sea by the Gulf Stream. Since Winge's study of the matter in 1923 (see *Geogr. Rev.*, Vol. 15, 1925, pp. 149–150) the consensus of informed opinion regards the vegetation of the Sargasso Sea as pelagic, living and propa-

gating vegetatively within the sea. Germain summarizes the arguments supporting this theory and refers to the fact that no forms intermediate between the species along the American coasts and those within the Sargasso Sea have been found.

A varied and specially adapted animal life is found in the Sargasso Sea. One striking feature of this fauna is that the various species it comprises have their analogues in coastal regions. That is, the fauna of the Sargasso is a littoral fauna isolated within a pelagic domain. The fish of the Sargasso Sea are especially interesting. Germain describes briefly the remarkable migrations of the European eels, which have their breeding grounds within the warm and saline waters of the Sargasso Sea and whose larvae appear later on the western shores of Europe and in the Mediterranean. Here the eels grow to maturity, and after five to seven years they return to the Sargasso Sea to spawn and die.

With regard to the origin of the Sargasso Sea, Germain inclines to the hypothesis of the foundering in Miocene time of an Atlantic continent that occupied the present site of the Sargasso Sea. On this hypothesis, the floating seaweed is only the remains of species that formerly were fixed to the shores of the foundered continent and that gradually adapted themselves to a pelagic regime. This would explain, too, both the absence of forms intermediate between this seaweed and the species growing on the American coasts and the littoral character of the Sargasso Sea fauna.

H. A. MARMER

PHYSICAL GEOGRAPHY

Visibility Studies in the French Colonies. Low atmospheric visibility, whether it takes the form of fog or merely of haze, is a menace to aerial navigation (see R. G. Stone's article, "Fog in the United States and Adjacent Regions," in the present number of the *Review*). As a consequence, the study of visibility, formerly more or less a matter of academic interest, has assumed great practical importance during recent years (see R. M. Williamson: Visibility, a New Element in Meteorological Observation, *Journ. Tennessee Acad. of Sci.*, Vol. 9, 1934, pp. 93–99; W. E. K. Middleton: How Far Can I See? *Scientific Monthly*, Vol. 41, 1935, pp. 343–346). "Visibility . . . is perhaps one of the most difficult of meteorological elements to define precisely and to reduce to numerical terms. This is partly due to its physiological character, the eye being the instrument used" (Cauvet-Duhamel: Etude d'un dispositif de la visibilité horizontale, *Annales de Physique du Globe de la France d'Outre-Mer*, Vol. 2, 1935, pp. 132–135; reference on p. 132). R. C. Jacobson of the Toronto Flying Club presents "A Vertical Visibility Scale in the *Bulletin of the American Meteorological Society* (Vol. 16, 1935, pp. 239–241) and reports that he and his associates" are now trying to devise a suitable instrument for aircraft use" in determining vertical visibility.

The article by M. Cauvet-Duhamel referred to above forms part of a symposium of studies under the title "Généralités sur la visibilité horizontale aux colonies" in the October, 1935, number of the journal cited. Besides a general discussion of the problem and Cauvet-Duhamel's paper, in which a practical method of measuring visibility is proposed, there are descriptive studies of visibility in French West Africa, French Equatorial Africa, French Cameroons, French Indochina, and French Somaliland. For all these colonies regional differences and seasonal variations in visibility are described and probable causes suggested. Particularly notable are two series of maps, one covering French Indochina and the other West Africa south of the Sahara and north of the Congo. Each series consists of a map for every month in the year 1934, showing the number of days during which horizontal visibility was reduced to less than two kilometers. Extremely poor visibility prevails at all seasons along the coastal fringe of French Cameroons, where in 1934 no month had fewer than 20 days when the visibility was less than two kilometers. In the Sudan visibility conditions

are worse in the dry season (December to March inclusive) owing to dust from the Sahara. In the interior of French Cameroons smoke from brush fires reduces visibility in the dry season. In French Indochina visibility conditions are dependent largely on the monsoons. Throughout the year visibility tends to be more favorable over the plains of Cambodia and Cochinchina than in the more mountainous regions of Tonkin and Annam.

OBITUARY

General A. W. Greely. In 1931 the American Geophysical Union, in view of the imminent observance in 1932–1933 of the second International Polar Year, passed a resolution, proposed by the Section of Meteorology, extolling General Greely's high achievement in the conduct of the station at Fort Conger, Lady Franklin Bay, Ellesmere Island, occupied by the United States during the first Polar Year of 1882–1883 and wished him continuance of good health. That this wish was fulfilled practically until his recent death in Washington (on October 20, 1935, at the age of 91) gave General Greely the unique experience of witnessing the repetition in another epoch of a scientific program in the first execution of which he had been an active participant. And, in spite of the rapid advance of science in the intervening fifty years and the larger number of stations involved in the second undertaking, the Fort Conger station in latitude 81° 44′ N. (not included in 1932–1933) remains the northernmost station ever occupied at which a continuous meteorological record has been kept (the Hooker Island station in Franz Josef Land occupied by the Russians in 1932–1933 is in 80° 19′ N.). A part of these observations are published in "International Polar Expedition: Report on the Proceedings of the United States Expedition to Lady Franklin Bay, Grinnell Land" (2 vols., Washington, 1888). That a large part of the records still awaited analysis and publication in 1923 was stated by General Greely (*Geogr. Rev.*, Vol. 13, 1923, p. 295) in accepting the Charles P. Daly Medal awarded to him that year by the American Geographical Society. The valuable exploratory work done on the Lady Franklin Bay Expedition in the interior of Grinnell Land, northern Ellesmere Island, and along the north coast of Greenland and the tragic hardships suffered by the expedition until the final rescue of the seven survivors of the original party of twenty-five are matters of polar history. Of these explorations a concise and objective account is given in General Greely's valuable "Handbook of Polar Discoveries," which, first published in 1896 and dealing with the Arctic alone, went through five editions, and in the latest edition (1928), somewhat expanded in economic emphasis, received the title "The Polar Regions in the Twentieth Century: Their Discovery and Industrial Evolution."

Meteorology and climatology in their broad setting, which was the concept underlying the Polar Year studies, with the two basic hemispheres, northern and southern, rather than countries or continents as their units of investigation, continued to be General Greely's specialty. Whatever work he did in this field was done on the background of a synoptic world view. In 1886 he was appointed Chief Signal Officer, U. S. Army, which office he held until 1906. Since 1870 the Signal Office had been charged with the meteorological work of the Federal Government, and General Greely directed this work until its transference to the Department of Agriculture in 1891 and the creation at that time of the present Weather Bureau. To this period belong his book "American Weather" (1888) and his government reports "The Rainfall of the Pacific Slope and the Western States and Territories" (*50th Congr., 1st Sess., Senate Ex. Doc. 91*, 101 pp., 1888) and "Report on the Climatology of the Arid Regions of the United States, with Reference to Irrigation" (*51st Congr., 2nd Sess., House of Repr. Ex. Doc. 287*, 356 pp., 1891). His close knowledge of Alaska gained in 1900–1904 during the construction by the Signal Office of 3900 miles of telegraph lines and submarine cables is reflected in his "Handbook of Alaska," first published in 1909 (3rd edition, 1925).

Alfred Rühl. Dr. Alfred Rühl, professor of geography at the University of Berlin, died on August 13, 1935, at the age of 53. The main aim of his later work was to contribute to the transformation of economic geography into a truly scientific study. His views on the requirements of theory and analysis necessary to elevate its standards are set forth in a preliminary paper (*Zeitschr. Gesell. für Erdkunde zu Berlin*, 1918, pp. 292–303); the practical application of these views is made in a masterly study of the development of agriculture in eastern Australia (reviewed in *Geogr. Rev.*, Vol. 22, 1932, pp. 163–164), this "new land" being chosen as an example because of the less complicated nature of the problem there than in the European countries hitherto usually made the subject of inquiry. Added evidence of Rühl's endeavor to penetrate to the heart of a problem, without concern as to whether the method of inquiry would be labeled economics, geography, or "geopsychology," to use the term he employed in an introductory way (*Zeitschr. Gesell. für Erdkunde zu Berlin*, 1913, pp. 128–138), is afforded by his series dealing with the economic mentality (*Wirtschaftsgeist*) of nations, in which Spain (reviewed in *Geogr. Rev.*, Vol. 13, 1923, pp. 150–151), the Orient, and the United States were discussed. His knowledge of the United States dates from his participation in the American Geographical Society's Transcontinental Excursion of 1912. To this period belong his paper on San Francisco in the Society's Memorial Volume of that excursion and a similar study of Newport News (*Zeitschr. Gesell. für Erdkunde zu Berlin*, 1913, pp. 695–712) that, among others, contains an excellent analysis of differential freight-rate structure. His earlier attention to geomorphology is reflected in his editorship of the German version of Davis' "Physical Geography" (under the title of "Die erklärende Beschreibung der Landformen," 1912), and the influence of Theobald Fischer, during his docentship at the University of Marburg (1909–1912), is evident in a number of papers on Mediterranean geography, among which two deal with the geographical basis of Italian emigration and Italian imperialism.

James Henry Breasted. Dr. James Henry Breasted, director of the Oriental Institute of the University of Chicago, died on December 2, 1935, aged 70 years. Dr. Breasted was a Corresponding Member of the American Geographical Society, and here it must suffice simply to note his geographical affiliations. In his presidential address before the American Oriental Society in 1919 Dr. Breasted, sketching the plans for the great institute he subsequently created, described the concern of the Orientalist as the "recovering [of] a great group of lost civilizations" (The Place of the Near Orient in the Career of Man and the Task of the American Orientalist, *Journ. Amer. Oriental Soc.*, Vol. 30, 1919, pp. 159–184). To the Orientalist was the task of bridging the gap between the natural scientist (the paleontologist with his dawn man) and the historian with the material provided by the early civilization of the ancient Near East. All data and observations revealing the conditions of life in these civilizations were to be considered relevant. "This address," it has been said, "marks a new point of departure in the study of history and of historical geography" (*Geogr. Rev.*, Vol. 8, 1919, p. 285). Dr. Breasted's breadth of vision and organizing ability are finding rich rewards in the several expeditions being undertaken by the Institute in Egypt and in Western Asia. Some recent results of the Prehistoric Survey of Egypt are published in this number of the *Geographical Review* (pp. 67–76). Another report on work of one of the Institute's expeditions, received by the Society through Dr. Breasted's kindness, is Dr. von der Osten's account of "An Unnoticed Ancient Metropolis of Asia Minor" (*Geogr. Rev.*, Vol. 18, 1928, pp. 83–92). Of Dr. Breasted's own writings reference can be made to two only: "A History of Egypt," first published in 1905, and "The Conquest of Civilization," 1926 (an amplification of "Ancient Times: A History of the Early World"). Both are written primarily for the nonspecialist, and both display an underlying appreciation of the geographical scene.

GEOGRAPHICAL REVIEWS

Norway in the Antarctic

Lars Christensen. **Such is the Antarctic.** Translated by E. M. G. Jayne. xiii and 15–265 pp.; map, ills. Hodder and Stoughton, London, 1935. 16s. 9 x 6½ inches.

This is the first book in English to provide a survey of that highly important part of recent Antarctic exploration represented by the Norwegian expeditions sponsored by the whaling industry. Consul Lars Christensen is head of the whaling firm that has sent out the vessels and fitted out the expeditions that have accomplished, either in the ordinary pursuit of their duties or on express errands, most of the discoveries and research, except those of Amundsen, to be credited to Norway in the South Polar regions. In so doing he has continued the tradition initiated by his father, Christen Christensen, in 1892 with the *Jason*, which in the season of 1893–1894 outlined a considerable part of the east coast of Graham Land, not recognized in its entirety until Wilkins' flight of December 20, 1928.

Consul Christensen himself took part in three voyages to the Antarctic, in his motor tanker *Thorshavn*, in the seasons of 1930–1931, 1932–1933, and 1933–1934, and the account of the experiences gained and the general reflections growing out of these voyages form a good part of the present volume. As he "intended this third voyage to be the final one of all my expeditions, both those in which I had actually taken part, and the others," (p. 254) and as the volume does not pretend to be a systematic account, a chronological list is here given of the expeditions sent out by Consul Christensen, with references to the scattered articles in which some of them have been described in English. In Norwegian there is a full account of these expeditions to and including the season of 1929–1930 in Volume 2 of Bjarne Aagaard's monumental history of Antarctic whaling and exploration (reviewed in *Geogr. Rev.*, Vol. 21, 1931, p. 517) published by the Whaling Museum of Sandefjord, which was founded by Consul Christensen after a study of the similar institution in New Bedford. There is also a brief synopsis, with a track map, in Article 1, dated 1935, of the volume of Scientific Results of these expeditions published by the Norwegian Academy of Sciences of which Article 3 has already been reviewed in these pages (*Geogr. Rev.*, Vol. 21, 1931, pp. 345–346).

The expeditions are: 1926–1927, *Odd I*, South Georgia to Peter I Island (Aagaard, *Scottish Geogr. Mag.*, Vol. 45, 1929, pp. 25–34); 1927–1928, first *Norvegia* expedition, Bouvet Island and South Georgia (*ibid.*, pp. 65–81); 1928–1929, second *Norvegia* expedition, Bouvet Island to Peter I Island and skirting of pack ice along 70th parallel between 90° and 123° W. (the only account of this sustained farthest south in this sector is contained in Aagaard's history, Vol. 2, pp. 658–662); 1929–1930, third *Norvegia* expedition, between Enderby Land and Coats Land, discovery of Queen Maud and Crown Princess Martha lands (*Geogr. Rev.*, Vol. 20, 1930); 1930–1931, fourth *Norvegia* expedition, circumnavigation of the Antarctic, discovery of Princess Ragnhild Land and skirting (by the catchers *Seksern* and *Torlyn*) of Lars Christensen Land, or Mawson's MacRobertson Land (*Geogr. Rev.*, Vol. 22, 1932); *Thorshavn*, sector from 85° to 30° E., discovery of Fram Bank, about 67° S. and 72° E. (the present volume, pp. 47–51); 1932–1933, *Thorshavn*, west of Enderby Land, Bouvet, Gough, and Tristan da Cunha islands, debarkation of Riiser-Larsen on ice off Princess Ragnhild Land for sledge expedition that was prevented by breaking up of the ice (*ibid.*, pp. 51–100); meteorological observations by nine floating factories for the International Polar Year; 1933–1934, *Thorshavn*, nearly complete eastward circumnavigation from 30° E. to Peter I Island, discovery of King Leopold and Queen Astrid Land just west of Kaiser Wilhelm II Land.

In addition to the accounts of these various expeditions the volume contains numerous details, some of them new, concerning the geographical features discovered, the technique of whaling, the questions of political sovereignty involved, and other matters.

On January 22, 1933, the whale catcher *Gvass* sighted an island in 68° 22′ S. and 36° E., which would place it in the offing of the large bay conjectured by Riiser-Larsen in 1930–1931 to be between Queen Maud and Princess Ragnhild lands (pp. 57 and 203). This island, as Thorshammer Island, is indicated on the 1935 edition of the 4-sheet chart of Antarctic waters in 1 : 5,000,000 by the Norwegian Whalemen's Assurance Association, a copy of which the American Geographical Society owes to the courtesy of Captain H. E. Hansen of the Norwegian Topographical Survey. On the 1933–1934 voyage of the *Thorshavn* Mawson's Douglas Islands could not be found, at least in the reputed position on the Antarctic Circle between 64° and 65° E. (pp. 258–259; it should be observed that Sir Douglas' revised map in the August, 1932, number of the *Geographical Journal* places them in 67° 20′ S. between 63° and 64°). Bouvet Island, in the search for which Dr. Gerhard Schott of the Deutsche Seewarte in Hamburg, oceanographer of the *Valdivia* expedition, was consulted in 1922 (p. 115) and which was made a dependency of Norway in 1930 (p. 143), is, because of the severity of the climate, to be classed only as a port of distress, where a ship may ride out a gale in the lee of the coast. The winter gales completely demolished the depot house erected there by the *Norvegia* in 1927 (p. 135), and it was not possible in 1928 to erect the meteorological station transported there for that purpose. The island appears to be a "dead point" as regards radio communication (pp. 140–141). Nevertheless, viewed broadly, Bouvet is a valuable *point d'appui* for the whaling grounds in this southernmost sector of the Atlantic (p. 145).

Although pelagic whaling is considered a recent development, called forth by the desire for emancipation from dependence on shore stations and the payment of corresponding license fees, the practice, in the sense of boiling the blubber on board ship, was carried on by the Basques in the sixteenth century and the Dutch, Norwegians, and British in the Arctic in the seventeenth and eighteenth centuries (p. 115). The slipway to haul the whale carcass into the hull of the ship is, of course, a recent invention. Wireless telegraphy for intership communication was first introduced in the season of 1913–1914 (p. 103). Wireless telephony is now in use (p. 59).

The question of political sovereignty is discussed with moderation and restraint (pp. 215–223). It is interesting to note that Consul Christensen in June and July, 1926, visited London and wrote to the Colonial and Dominion offices notifying them of his plan to undertake whaling in a new district, namely between the South Shetlands and the entrance to the Ross Sea, and applying for a license to permit access to the harbors and islands in that district, Peter I Island and Dougherty Island (later proved nonexistent) being specifically mentioned in the application. In January, 1927, when the *Odd I* had already been on the whaling grounds for some time, he was informed by the Dominion Office that the matter had advanced to a point where the government of New Zealand was willing to draft a general license on the basis of Dougherty Island, which was claimed as British. Incidentally, in view of Admiral Byrd's explorations, it is also interesting to note that the same communication maintained that the sector between 80° and 150° W. was under Great Britain and should be administered by New Zealand (pp. 27–29).

As to Norwegian claims in general, Consul Christensen, recognizing the reality of the sector principle while not favoring that principle, is of the opinion that these claims ought to include all of what he calls "the Norwegian mainland" from 50° E. to 15° W. (this overlaps 5° with the recently established Australian Dependency and leaves a gap of 5° toward the Falkland Dependency), a special exclave between 60° and 75° E. (i.e. between Enderby and Kaiser Wilhelm II lands within the Australian Dependency), and the sector between 80° and 100° W. of the conjectured mainland

facing Peter I Island (p. 222). "Is it to be wondered at that, having staked so much upon the whaling industry, we should feel that we have a great deal to safeguard in the Antarctic? We will gladly discuss with all interested parties the possibilities that exist for a rational whaling industry. But we feel we have a certain right to carry on whaling, particularly in the areas which have been discovered and rendered workable through the Norwegian whaling industry."

Population Theories and the Japanese Population Problem

E. F. Penrose. **Population Theories and Their Application, with Special Reference to Japan.** xiv and 347 pp.; index. (Food Research Inst. Misc. Publs. No. 7.) Stanford University, Cal., 1934. $3.50. 9 x 6½ inches.

Mr. Penrose came from Nagoya Commercial College to Stanford University under the combined auspices of the Social Science Research Council, the Institute of Pacific Relations, and the Food Research Institute to conduct a research project, of which the volume under review is the first published result. The project was concerned with studies of food and population in the crowded areas of the Far East. The Institute of Pacific Relations found these problems of food and population underlying practically all the more practical contentious issues of political conflict. The present volume, therefore, is primarily a study of population pressure in Japan. Not only is Mr. Penrose well informed regarding both Japanese and non-Japanese discussions of this subject, but his long residence in Japan gives him unusual familiarity with local conditions and attitudes. Moreover, he brings to the study what is obviously a keen, critical, and even skeptical mind, which brushes aside facile interpretations and insists on factual bases for any conclusions that may be reached. The result is a clear, realistic, and balanced study, at once less sensational but more convincing than many statements hitherto made. He dismisses the mystic influence of family and ancestor worship and rightly ascribes the expansion of population in recent decades to more ordinary factors such as the absence of contraceptive knowledge and appliances when the limits of subsistence were raised suddenly. The persistence of this increase is largely explainable by the age grouping of the population. A cycle of increase, once begun, has to run its course. The birth rate is, however, falling as the fertility rate has been falling for many years.

As a careful, well documented study of Japanese population this volume is very useful; but it has greater values than that, since, both at the beginning and at the end, it goes deeper and wider than a mere statistical and descriptive study.

The first three chapters are an extremely compact, closely reasoned analysis and criticism of the concepts currently used in discussions of population problems. Throughout the whole volume it is apparent that Mr. Penrose has more to say than can be said at length. His style is clear, but at times his argument is so closely packed as to require intensive reading. Indeed, one has the impression that, if circumstances had allowed, three volumes might have been written, the first on population theory, the second on the Japanese problem, and the third on the wider applications of population pressures. If there had been more space at his disposal, Mr. Penrose might have developed his theory more fully and allowed himself greater latitude of exposition and illustration in the descriptive and applied sections of his book. On the other hand, there is some advantage in having all three phases treated in one short volume. The book is at once a penetrating theoretical study, a balanced description of a particular problem, and a suggestive synthesis.

It is Mr. Penrose's analytical ability that is most evident in the opening chapters. Beginning with Malthus, he manages briefly, but without loss of essentials, to outline the salient features of population theory. In doing so he subjects the main concepts, such as income, welfare, optimum population, to searching critical analysis. Students of population will need in future to refer to these pages.

Finally he broadens his discussion to take in more general issues to which population pressure contributes some urgency—migration, territorial expansion, international trade, and political conflict. It is not usual to find this combination of critical theory, adequate statistical and current observation, and imaginative synthesis. At the present moment the world resounds with the pleas and plaints of those who demand rights of expansion because of population pressure. Mr. Penrose's sane discussion of these questions comes therefore as a timely contribution to an actual question.

J. B. CONDLIFFE

PREHISTORIC CHINA

J. GUNNAR ANDERSSON. **Children of the Yellow Earth: Studies in Prehistoric China.** xxi and 345 pp.; map, diagrs., ills., index. George Routledge & Sons, Ltd., and Kegan Paul, Trench, Trubner & Co., Ltd., London; The Macmillan Company, New York, 1934. $6.50. 8½ x 6 inches.

Dr. Andersson went to China more than a score of years ago under appointment to the government as adviser in economic geology. In this capacity he was immediately successful. Soon, however, he was irresistibly drawn to the investigation of other fields, notably those of paleontology and archeology. Here too he made many discoveries of epochal importance. Of his work along these varied lines he tells us most interestingly in his new book.

The volume opens with a survey of the earlier geological periods. In Chapter 4 the author shows how the orogenetic forces at work in China have helped mold her present-day topography, and in Chapter 5 he treats of the Chinese dragon concept and its complex origins.

As long ago as 1921, the discovery, in the now famous cave of Chou K'ou Tien near Peiping, of a few bits of quartz, apparently artificially broken, inspired Dr. Andersson to declare that the site would one day reveal some form of ancient man. How abundantly his prophecy has since been fulfilled by the discovery of "Peking Man" is known to all. Chapter 6 gives us an excellent description of that remarkable and very primitive human type.

Archeologically, decidedly the most significant of Dr. Andersson's discoveries is that of the Neolithic culture called Yang Shao after the type site and characterized by fine painted pottery strikingly reminiscent of similar wares found in southern Russia. Dr. Andersson also unearthed in northwestern China evidences of a Chalcolithic period, with a slight but growing acquaintance with metal (whether copper or bronze is not made clear). To these revelations concerning China's prehistoric past the author devotes eight chapters (10 to 17 inclusive). He follows these with a discussion of folk beliefs about life and death as they seem to be symbolized in the designs on the prehistoric painted pottery. In his final chapter he tells us of the conclusions that he has drawn from his discoveries.

Dr. Andersson has exceptional gifts as a writer. He writes, too, with the authority possible only to one completely master of his subject. He is careful always to distinguish between personal observations and hearsay or surmise, and when he mentions work done by others he gives the fullest and most generous credit. The accounts of his explorations show him to possess courage, persistence, and good humor, together with a sympathetic insight into the thought processes of the illiterate peoples among whom he worked.

Dr. Andersson's tentative dating of the prehistoric Chinese cultures puts their earlier phases around 3000 B.C. This has seemed considerably too early to other investigators, both Chinese and Occidental. Several of these have independently reached the conclusion (see, for example, p. 336) that the Neolithic Chinese painted-pottery culture probably flourished during the closing, rather than the opening, centuries of the third millennium before Christ, and the succeeding Chalcolithic

stage should be assigned to the period around 2000 B.C. As the author states, the question of dating can be settled only after further research.

Dr. Andersson dismisses the idea (p. 172) that the pits found on Yang Shao sites can have been dwellings, because he feels that the "inhabitants had a much too rich and comprehensive furniture to have lived in such confined cabins." But this, as later investigations have shown, is precisely what they did do. Moreover, such pit dwellings continued to be the habitations of the masses far on in the subsequent Chinese Bronze Age, and the unconquered aborigines of northern China were still living in them many centuries later.

The term "Bronze Age" as applied (pp. 259, 260, and elsewhere) to the Chalcolithic period in China, when metal of any kind was barely beginning to be known, is a misnomer; it should be restricted to the brilliant though archaic civilization of early historical times. Confirmation is lacking for the author's implication (p. 156) that the domestication of cattle took place independently in the Far East; rather, it seems increasingly probable that cattle breeding was introduced there as a culture loan from the Occident. Dr. Andersson's suggestion (p. 182 and elsewhere) that the socketed metal celts used in China were evolved on the spot from forms in stone will probably not stand, for no intermediate forms have been found; whereas socketed bronze celts occur over a wide but definite region of the Eurasiatic continent, with the center of diffusion apparently in Central Europe.

The "genuine Neolithic age" of northern China can no longer be described as "dark and unknown" (p. 336), for its remains occur throughout the entire area. The Yang Shao painted pottery, on the other hand, has so far appeared only in localities adjacent to the great transcontinental migration route, from Chinese Turkestan on the west to southern Manchuria on the east.

The book is well supplied with plates and line drawings inserted exactly where they belong in relation to the text, and there is a useful map. The diagrams and tables are helpful, and the documentation is full. There is a brief but carefully prepared index. The translation from Swedish into English has been admirably done by Dr. E. Classen.

"Children of the Yellow Earth" could have been written by no one but Dr. Andersson, with his extraordinary range of interest and experience and achievement. As informative as it is delightfully written, it forms a contribution of outstanding importance to our knowledge of China's past. The author fittingly inscribes the book to the memory of the late Dr. Davidson Black, whose untimely death early in 1934 was an irreparable loss to science.

C. W. BISHOP

THE STEPPES OF THE NEAR EAST AND EARLY CIVILIZATIONS

ROBERT GRADMANN. **Die Steppen des Morgenlandes in ihrer Bedeutung für die Geschichte der menschlichen Gesittung.** 66 pp.; maps, ills., index. *Geogr. Abhandl.*, Ser. 3, No. 6. J. Engelhorns Nachf., Stuttgart, 1934. 9 x 6 inches.

The Orient (in this connection southwestern Asia and Egypt) is one of the oldest centers of civilization. This is largely because the region is one of steppes, a fact on which not enough emphasis has been laid in the past. The steppes gave cereals to mankind—for the cultivation of grains long remained impracticable in wooded regions. The margins of the steppes provided fruit trees—the fig, olive, etc.—as well as the vine. In the steppes irrigation was developed at an early period, and states were organized for the defense of productive resources against the nomads; out of this sprang the earliest urban communities of ancient times. Offering easy natural lines of communication, the steppes saw the beginnings of trade, even of international trade. Hence, according to Professor Gradmann, the steppes have a just claim to being regarded as the cradle of civilization.

But are there steppes in the Orient? This is what the author wished to verify for

himself in 1933 in the course of a two months' journey through Palestine, Trans-Jordan, and the neighboring regions as far as Damascus on the north and Suez on the south. He first describes the characteristics of steppe, desert, and wooded country in terms of vegetation cover and rainfall. On sketch maps he shows the areas where these different types of vegetation prevail. Woodlands are found along the Mediterranean and in a narrow western fringe of Trans-Jordan; the desert extends northward to the middle Euphrates and also sends a tongue well to the north into El Ghor beyond the Dead Sea. Between woodlands and desert a band of steppes intervenes. This widens toward the northeast into the broad tract including most of Palmyrena and upper Mesopotamia, where the earliest civilizations of the steppes were born.

An objection to this theory might be raised on the ground that the vegetation of these areas has been modified by the hand of man or by a change in climate. The presence of plants in their ancient habitats, however, is demonstrated in the case of indigenous varieties, such as *Triticum dicoccoides*, always found in steppes. Professor Gradmann does full justice to an alleged change in climate in a manner that, to the reviewer, seems altogether irrefutable. The steppes may well be regarded as having existed since the dawn of civilization, a circumstance that goes far toward explaining not only the antiquity of the Orient's development but also its stagnation at the present time.

RAOUL BLANCHARD

BLACK AFRICA

JACQUES WEULERSSE. **L'Afrique noire, précédée d'une vue d'ensemble sur le continent africain.** 484 pp.; maps, diagrs., bibliogr., index. (Géographie pour tous.) A. Fayard & Cie., Paris, 1934. 25 fr. 9 x 5½ inches.

There must be a large number of the French people who are interested in Africa, and it is perhaps surprising that they have had to wait so long for a French geographer to give them a general work on the continent that will appeal to them. It was thus a well justified project to produce in the series "Géographie pour tous" such a work in two volumes, the division based on the fact that racially and culturally there are two Africas. The northern region, that of the "whites," is left to be dealt with by E. F. Gautier. M. Weulersse, therefore, has given us a detailed study of the Africa of the black folk, but he has prefaced this with a general geographical account of the entire continent, which is in many ways a model.

Although the book is doubtless intended primarily for French readers, it is certain that many others will welcome it as the work of a skillful author. M. Weulersse has the gift of easy writing, yet he never allows his apt metaphors to carry him away. He provides a large measure of matter culled from the most modern scientific works as well as from historical, economic, and political sources; yet the result is far from heavy, since he knows how to make a geographical synthesis. His vivid descriptions seem to emanate from his own personal experience; if not, they are exceedingly well chosen from that of others. Examples that help his descriptions of climate are a vivid account of a West African tornado (p. 108) and his characterization of Nigerian contrasts: "At Lagos Christmas is celebrated in the hum of fans vainly beating the equatorial night air, while at Jos on the Bauchi plateau other celebrators are drinking steaming punch by the fire" (p. 191). Such realistic weather notes have their analogues in word pictures of vegetation, land forms, native village life, and so on. But they do not detract from the systematic character of the work, which deals in turn with West, Central, South, and "Indian" Africa. Each of these is again subdivided politically—a method with defects of which the author is aware. But the advantages are clear in view of the differing methods of colonization. Moreover, two of the subsections—the Belgian Congo and British East Africa—are largely from the pen of a collaborator, M. Pierre Daye, who has included some political information

less obviously linked with the geography than is the case elsewhere. The reader receives much help throughout from a large number of well drawn maps.

M. Weulersse makes no attempt to compare the methods of Europeans in contact with Africans, but his accounts of these contacts and their results are effective and objective. His dictum regarding South Africa may be mentioned. Here, he points out, Europeans have settled *alongside* the blacks, and, save in the Portuguese colonies, "there is a fundamental opposition of the two ethnic elements, a real duality of human geography, perhaps without equivalent elsewhere in the world" (p. 333). Elsewhere (p. 89) in introducing the black race he states that "this racial dust, of peoples and tribes, is beginning to agglomerate into vast distinct organisms. Peoples are becoming conscious of themselves. The danger is that this crystallization takes place against Europe. . . . No colonizing people can run counter to the law of numbers, which gives Africa to the Africans. Every work created against—or even without—the native races, white, brown, or black, is ephemeral and condemned in advance."

A. G. OGILVIE

RESEARCH ON DEPENDENCIES AND NATIVE PEOPLES IN THE PACIFIC

FELIX M. KEESING AND MARIE KEESING. **Taming Philippine Headhunters: A Study of Government and of Cultural Change in Northern Luzon.** 288 pp.; maps, ill., bibliogr., index. Stanford University Press, Stanford University, Cal., 1934. $2.75. 8½ x 6 inches.

FELIX M. KEESING. **Modern Samoa: Its Government and Changing Life.** 506 pp.; diagrs., bibliogr., index. Stanford University Press, Stanford University, Cal., 1934. $4.00. 8½ x 6 inches.

These two books are products of field studies carried out under a research project of the Institute of Pacific Relations dealing with "Dependencies and Native Peoples in the Pacific." The volume on the Philippine headhunters has a special, timely interest, dealing as it does with a "colonial" problem that must be faced by the independent government of the islands. The non-Christians of the Mountain Province of Luzon number less than a quarter of a million. So far they have largely maintained their integrity. "Within clear sight of the capital, Manila, itself are mountain regions where live folk hardly affected during the four and a half centuries of western rule from that centre." What is their future to be? The Mountain Province (5350 square miles) holds out no very attractive economic prospects, for either the present inhabitants or the lowlanders who might turn there. Some parts are indeed already overpopulated. The mountaineer, holding firm to a life akin to that crushed elsewhere by the Spanish system, resists outside cultural influences.

"Is it best for the Mountain Province to be cut up progressively, or for the mountain peoples as at present to be held together in a formal political unity? . . . Which is better for the future Philippines—assimilation of the mountain peoples by piecemeal absorption or by building national loyalties on the remarkable structure of existing local loyalties? Must the rich patterns of the mountain life be smashed entirely to make the people into Filipinos?"

From one aspect the Philippine problem has a simplicity not found, for instance, in the Samoan or other Pacific islands. The highlander of northern Luzon is assimilable; no unbridgeable gulf of race or culture separates him from the lowlander. In Samoa the clash of alien civilizations has resounded during a century of stormy political history. The population of Western Samoa and American Samoa together is not more than that of a good-sized town (less than 55,000), but the problems the Samoas offer are complicated in the extreme. To the student of political geography the mandatory regime in Western Samoa is of particular interest both in itself and in the wider application to the system of mandates in general. The friction of its opera-

tion here is not to be explained by either the "cussedness of the Samoans" or the "sinister intrigues of the local Europeans" or the "tyranny of the New Zealand authorities" alone. It is the relations between these three elements, native, white planter, and government—to which may be added a fourth, the introduced Chinese contract labor—that make the problem.

Beyond economic considerations is the question of the whole philosophy of the native life. "There is taking place in Samoa a collision of extremely contrasting philosophies and ways of living with many fundamentally incompatible elements. The indigenous culture, aided by environmental conditions and native inertia, shows great tenacity. Due to geographic isolation the western culture is arriving in heterogeneous and attenuated form, hence while proving a powerful agency of disintegration it does not present any complete and satisfying basis for reintegration." In Samoa nature affords the traditional easy living of the South Sea Islands. In the well known phrase of La Pérouse, the Samoans were "undoubtedly the most happy inhabitants of the earth." An observer during German rule describes their routine thus: "On Fridays their plantations are scantily worked, and provisions for a week are procured; the other six days are days of rest and play, pleasantly relieved by hunting, fishing, and practising for church." In contrast with the economic philosophy of the West, the Samoan gains prestige and authority through generosity in distributing wealth rather than through sagacity in accumulating it. "To a Samoan the whole of Samoa is a great free boarding house." He resents official restrictions on "wasteful" indulgence in his favorite sport of cricket and the ancient custom of ceremonial visiting. The questions raised are how far such practices are "wasteful" from the viewpoint of native psychology and, taking them as symbols, how far government control is warranted. Is there a danger of overprotection, of cultural pauperization?

In such fashion Dr. Keesing surveys the Samoan problem in its ramifications. Here and in the book on the Philippine headhunters he makes clear the inadequacy of our knowledge of native peoples and native ways of life. With the best intentions in the world the governing authority may do the wrong thing, as when modern forest-conservation measures in northern Luzon threatened native hunters with starvation. In both studies Dr. Keesing has had the aid of his wife, and between them they have produced two excellent volumes—strictly impartial and sympathetic in tone, penetrating in analysis but hopeful in outlook.

Nature and Man in Iceland

Walter Jwan. **Jsland: Studien zu einer Landeskunde.** 155 pp.; maps, diagrs., ills., bibliogr. (Berliner Geogr. Arbeiten, Geogr. Inst. der Univ. Berlin, No. 7.) J. Engelhorns Nachf., Stuttgart, 1935. 9 x 6 inches.

Iceland is a land of natural conflicts: the land and its surroundings present the elemental conflict of fire and water. For untold centuries before the first venturesome Norwegians landed on the shores of this strange unpeopled country the natural forces that molded its form and determined its habitability were opposed. During the last millennium, with Nature still engaged in guerrilla warfare, man has struggled for an existence that has rarely risen above the meager standards of the marginal sub-Arctic settlement.

In this well arranged and abundantly illustrated memoir, based on published information supplemented by personal observations, Walter Jwan has caught something of the drama that has unfolded itself in Iceland. About four-fifths of the text is devoted to an outline of the geology and physical geography of the country; these parts, largely condensed from the voluminous writings of Thoroddsen, furnish a convenient summary of rather familiar material. Although brief, the remainder of the text gives an informative account of the people of Iceland and their mode of living.

Human progress having been marked in newer lands by repeated increase of popu-

lation in recent historical times, the slight changes in the number of Iceland's inhabitants during the last thousand years indicate a near balance between the efforts of man and the opposition of Nature. Iceland was colonized early in the tenth century by vigorous immigrants who came from Norway and in much smaller numbers from the Orkneys and the Hebrides, and the population grew to 50,000 by the end of the century. In the heyday of the flourishing free state the population may have reached 80,000. Toward the end of the Middle Ages Iceland began to decline; the highland pastures were abandoned, and the trails across the high plateaus and ice fields of the interior were forgotten. Danish trade monopolies impoverished the country, and by the end of the eighteenth century the population was reduced to 38,000. The great catastrophe of the Laki eruption struck an enfeebled people, given to drink and lacking all enterprise; one-fifth of the population perished and two-thirds of the cattle. By 1880 the population had increased again to 72,000; today, as a result of the development of frequent steamer service, highly productive fisheries, and important industrial enterprise, the population stands at 110,000, of whom 30,000 live in Reykjavík.

With a wealth of detailed information in 28 pages of assembled notes, an index map to the illustrations, a bibliography of 623 titles, a list of maps, and an index of place names, Jwan's able memoir is both an introduction to the geography of Iceland and a guide to deeper study.

M. A. PEACOCK

THE REGION OF THE RHINE

ALBERT DEMANGEON AND LUCIEN FEBVRE. **Le Rhin: Problèmes d'histoire et d'économie.** xii and 304 pp.; maps, diagrs., bibliogr. Librairie Armand Colin, Paris, 1935. 26 fr. 9 x 5½ inches.

For centuries the Rhine Valley has been a region of dense population and intense human activity. Nor has it lost prestige today, since recent discoveries and scientific inventions in the hands of the progressive people have greatly increased the value of the various natural resources. No other part of Europe can claim so many fine old cities, centers of ancient culture, interspersed with so many prosperous new ones. Here capital has continually attracted population and encouraged the development of enterprise.

Today the Rhine carries a large fleet of vessels belonging to several countries, with a capacity of 5,500,000 tons. In 1914 the tonnage on the river was divided among the nations as follows: Germany, 50 per cent; Netherlands, 38; Belgium, 12. The war changed these percentages, reducing that of Germany (31.9 per cent in 1928) and raising that of the Netherlands (45.5); French vessels also began to be important (5.2). In terms of horsepower, however, the German percentage is the largest (46.3 per cent in 1928), and Germany really controls the Rhine traffic. Shipping firms depend on Germany for capital and for the personnel of their ships.

This international movement following the waterway represents only a part of the movement of freight and passenger traffic across the Rhine countries. Owing to its central location, international railroad lines converge on the region from all directions. The large cities—Cologne, Frankfurt, Strasbourg, Basel—are all great railroad junctions. As many as 500 trains a day arrive and depart from Frankfurt, and similar traffic penetrates all parts of the Rhineland. The recent economic crisis has caused a decline in the output of German heavy industries and in the export of iron ore and potash. This has made it increasingly difficult for the river to compete with the railroads; but it is hoped that as conditions become normal the Rhine will again carry her fair share of merchandise.

Commercial activity usually produces industrial activity. The evolution of the ports from commercialism to industrialism is largely the result of their situation on the Rhine, since by this route raw materials and fuel from the entire region can be assembled and manufactured goods transported to markets. There is a continuous

line of urban settlement along the banks of the Rhine, the largest cities being at nodal points where east-west routes cross the valley. The great urban expansion began with the Industrial Revolution, and rapid growth took place during the nineteenth century. The cities developed new forms or patterns, absorbing the population of the outskirts, with the river as the great central thoroughfare. Mülheim and Kalk; Duisburg-Hamborn, Ruhrort, and Meiderich; Rotterdam and its environs —all form such agglomerations.

The recent economic expansion of the region is seen not only in the development of the metallurgical and textile industries but also in the increased use of electrical energy. A network of transmission lines carries this energy far and wide, aiding industry and binding outlying areas to this great economic unit. Industry owes an immense debt to the famous banking houses, which have sustained not only the metallurgical, textile, chemical, electrical, and other industries but also shipping, commercial, and insurance companies.

The main thesis of this clear, concise, and well organized volume is that the present economic conditions and human activities of the Rhine are not a political achievement and cannot be explained apart from the geographical and historical background. After considering the writers' forceful arguments, novel in aspect, with no word of political rancor, the reader is convinced that the region of the Rhine, though diverse and extremely complex, is a definite natural region, held together and unified by its central artery—the river itself.

The book is divided into two main parts; the first is historical, and the second deals with natural resources and the work of man. The illustrations include excellent maps of the maritime and river ports and of the Rhine showing the tonnage upstream and downstream and the amount of merchandise moving from the different Rhine ports. A classified list of French and German references is appended. (Perhaps it was an oversight that a few in English were not included.) An English translation would doubtless be acclaimed by American and English students.

E. Muriel Poggi

Scolt Head Island, Norfolk

J. A. Steers, edit. **Scolt Head Island: The Story of Its Origin: The Plant and Animal Life of the Dunes and Marshes.** xvi and 234 pp.; maps, diagrs., ills., bibliogrs. Published for the Norfolk & Norwich Naturalists' Society by W. Heffer & Sons Ltd., Cambridge, 1934. 15s. 8½ x 5½ inches.

On the Norfolk coast of eastern England are found an interesting variety of bars, spits, forelands, and other shore forms. One of the bars, known as Blakeney Point, has long been a center of botanical and other researches conducted by Professor F. W. Oliver and his associates. The Point now constitutes what in England is called a Nature Reserve and is administered by a National Trust, which places the areas it controls under the active management of a local committee. In this way desirable areas are withdrawn from private ownership and, like our own national parks and national monuments, are held in perpetuity as natural reserves for the benefit and enjoyment of the people.

Recently another coastal bar, more inaccessible to the public than Blakeney Point and therefore better fitted for researches with natural conditions little changed by human agencies, has been transferred to the National Trust. This is Scolt Head Island, also on the Norfolk coast. Physiographically the island is part of an offshore bar whose skeleton consists of compound recurved gravel ridges that record the progressive growth of the island from east to west and the westward migration of an inlet connecting with marshes and waters behind the bar. The gravel ridges are augmented and partially obscured by beach and dune sands, more or less overgrown by shore vegetation; and marine muds and marsh occupy the lower ground. Sub-

merged forests and peat beds are found at places along the shore and in tidal channels. Four species of tern breed on the island; other bird life and a few mammals are present; and the adjacent waters have a reasonably abundant fauna.

Such is the setting that makes of Scolt Head Island an admirable research laboratory. Not only the geomorphic evolution of the island itself but also the relations of plant and animal life to a variety of physical zones may be studied. The physical contrasts are often notable; for example, that between the eastern ridges and swales, which were formed first, and those recently formed at the extreme west. Westward one traverses a beautifully graded series of interridge marshes, from the "mature vegetated high marsh (salting) in the east, to bare slob lands, but recently won from the sea, in the west." The geographic consequences of these physical conditions must alone present abundant problems for study; and these by no means measure the full possibilities of the area as a natural research laboratory.

To make the most of these possibilities has been the ambition of Mr. J. A. Steers, dean of St. Catharine's College and university lecturer in geography, and of his geographical and other associates at Cambridge, England. An early suggestion by Professor F. W. Oliver, frequent visits to the island by Mr. Steers and his students, the coöperation of university colleagues and others have marked successive stages from the conception of this idea to its full realization. What may be called the first fruits of the enterprise (a more complete edition is suggested for the future) are embodied in the volume under review.

Edited by Mr. Steers, the book carries a foreword by John Buchan and consists of chapters by some eleven contributors dealing with the history of the enterprise (by Sydney H. Long), the physical evolution of the island (J. A. Steers), the petrology of the beach pebbles (F. Coles Phillips), pollen analysis of the peats (H. Godwin and M. E. Godwin), plant ecology (V. J. Chapman), Bryophyta (C. V. B. Marquand), lichens (Carola I. Dickinson), mammals (E. A. Ellis), breeding birds (E. L. Turner), marine invertebrates (D. L. Serventy), and nonmarine Mollusca (E. A. Ellis and Charles Oldham). The final chapter is a summary of the geographical and related problems of the region, written by F. Debenham, professor of geography in the University of Cambridge. Numerous maps, diagrams, and reproductions of photographs abundantly illustrate the text. To the chapters are appended appropriate bibliographies. Unfortunately there is no index, and important places mentioned in the text sometimes appear on the maps in different form or do not appear at all.

The work is a valuable outcome of the activities of Mr. Steers and his associates and a serviceable guide to those fortunate enough to visit Scolt Head Island. It places a larger public in touch with one phase of the home geographical activities of a university where interest in polar exploration has recently been signalized by the completion of a new home for its school of polar research.

DOUGLAS JOHNSON

THE GLACIAL FEATURES OF CAPE COD

J. B. WOODWORTH AND EDWARD WIGGLESWORTH. **Geography and Geology of the Region Including Cape Cod, the Elizabeth Islands, Nantucket, Marthas Vineyard, No Mans Land and Block Island.** xvi and 322 pp.; maps, diagrs., ills., bibliogrs. *Memoirs Museum of Comparative Zoölogy at Harvard College*, Vol. 52. Cambridge, 1934. $15.00. 12 x 10 inches.

The partly submerged coastal plain of New England, important because of its drift-border features, was early studied by Shaler, whose well known reports on the Cape Cod region have become classics in geology. Woodworth entered the field as Shaler's assistant, and after intermittent work extending through many years he spent the seasons of 1914 and 1915 on intensive study, with Wigglesworth's independent assistance. After delays amounting to nearly twenty years, the work led to the present publication, which is posthumous for the senior author.

The memoir gives as thorough an account of the geology of the region as the rather limited exposures permit, for the deposits of the last glaciation mask the surface effectively. Necessarily the greater part of the memoir is devoted to the Pleistocene features, which, except for those of late-glacial date, are exposed in section in a few wave-cut cliffs.

The correlation of the various layers is based partly on the concept that each major advance of the ice is represented by a threefold deposit consisting of (1) outwash laid down before the advancing ice, (2) till, (3) outwash laid down beyond the wasting ice. This ingenious concept envisages a repeated sequence of events so ideal that it is difficult to harmonize it with the complex of conditions obtaining along a major ice front.

The authors have worked out an involved Pleistocene history, based on the exposures. They have correlated closely the sequence of events in the Cape Cod region with that developed by M. L. Fuller (*U. S. Geol. Survey Professional Paper 82*, 1914) for Long Island. This involves four glacial stages, tentatively correlated with the four stages now recognized in the standard section of the Middle West.

Although the reviewer cannot agree that this complex subdivision is justified by the facts presented by Woodworth and Wigglesworth (see his discussion, "How Many Glacial Stages Are Recorded in New England?" *Journ. of Geol.*, Vol. 43, 1935, pp. 771–777), there can be no question of the great value of this work for students of the Pleistocene. Descriptions of the sections are given in admirable detail, and the field relationships are plotted so fully on large-scale base maps that future investigators will be able to grasp the authors' ideas and visit their type localities with great ease. A detailed discussion of modern eolian activity, involving dunes and numerous ventifacts, and modern shore processes is supported by a wealth of historical references. A voluminous bibliography accompanies each chapter of Part 2. The volume is a fine piece of bookmaking, its format befitting the extensive, thorough, almost encyclopedic character of the excellent study it sets forth.

RICHARD FOSTER FLINT

THE WEATHER

CHARLES FRANKLIN BROOKS, with the collaboration of Eleanor Stabler Brooks and John Nelson. **Why the Weather?** xvii and 295 pp.; diagrs., ills., index. Harcourt, Brace & Co., New York, 1935. $2.50. 8 x 5¼ inches.

The weather is a popular subject, and newspapers frequently publish short articles on curious weather phenomena; but unfortunately "Our Correspondent" is not always a good scientist, and some of his explanations are even more curious than the phenomena. Dr. C. F. Brooks did good service for meteorology in America when he undertook the preparation of a series of authoritative notes for circulation to the press. The first collected edition of these notes, published in 1924, proved a valuable addition to the literature of popular meteorology. The second edition is considerably enlarged to include a good deal of new material and especially many really beautiful photographs.

The collection makes bright and interesting reading; but although the notes are roughly classified according to the season, they remain a rather disconnected series, difficult to review. All the usual subjects of a textbook are dealt with—although not in a textbook manner—and also many unusual subjects of practical interest to the public, such as "dressing for the weather" and how to keep houses warm in winter and cool in summer.

The author's claim of accuracy in presentation is justified; the reviewer could find only two small points for criticism. The fact that the doldrums in the Atlantic are always north of the equator is attributed to the larger land mass in the northern hemisphere; but probably the unequal division of the warm equatorial current

between the northern and southern hemispheres is more important. The statement on page 196 that "the heavier gases form a larger proportion of the lower atmosphere than they do of the higher," although probably true in theory, has not yet been proved by observation.

The book is likely to be widely read in England as well as in America, and it would have been worth while to add footnotes to a few of the paragraphs pointing out that some weather terms differ in the two countries. For example, in England "sleet" is a slushy mixture of rain and snow, and the English reader will be puzzled to read that one can "hear it rattling on roofs and window panes." Fortunately such terminological differences are rare, and for the most part Americans and Englishmen still talk the same language. The index, which covers nine pages, is really helpful, and the general make-up of the book is excellent.

C. E. P. Brooks

The Erosion Problem

Paul B. Sears. **Deserts on the March.** 231 pp., ills. University of Oklahoma Press, Norman, 1935. $2.50. 8 x 5¼ inches.

R. Maclagan Gorrie. **The Use and Misuse of Land.** 80 pp.; diagrs., ills., bibliogrs. *Oxford Forestry Memoirs No. 19.* Clarendon Press, Oxford; Oxford University Press, New York, 1935. $2.00. 11 x 7½ inches.

The writing of "Deserts on the March" was begun during the recent epidemic of dust storms in the West and completed during a period of phenomenal rains with storm waters sweeping vast quantities of rich farm soil into the rivers. Vivified by personal experience and telling example, brought home by forceful style and familiar expression, Dr. Sears's book is a challenge to the thoughtful citizen to "do something" about the waste of the greatest natural resources of his country. In dramatic fashion "Deserts on the March" presents "Man" as a "Maker of Wilderness." After a prologue in the Old World the scene is shifted to the United States, to civilized man's westward march through successive forest, grass, and desert belts.

The desert Dr. Sears defines by the amount and quality of its life. Equilibrium in a natural vegetational association, whether of forest or grassland, is delicate and closely bound up with the supporting soil. Disturb the balance and a host of consequences are set up. Natural grassland is remarkably flexible to climatic variation; it is likely to be quite otherwise with the cultivated crop that replaces the native sod. There is more to scientific agriculture than the production of two blades where one grew before, for there may come years when half a blade is all that can be had. There is no one sovereign remedy for erosion. Dust storms are only a "symptom and a symbol" of a highly complex problem. The recent storms of the West have served a useful purpose in focusing attention on it, thereby aiding in the establishment of the Soil Conservation Service of the United States Department of Agriculture. But, points out Dr. Sears, the service has to operate in a democracy and cannot develop effective strength beyond that which public sympathy and support will confer upon it. "Science has the power to illuminate, but not to solve, the deeper problems of mankind. For always after knowledge come choice and action, both of them intensely personal and individual."

Some aspects of the erosion problem in the United States as seen by an outside observer are given in "The Use and Misuse of Land," the most recent number in the excellent series of *Oxford Forestry Memoirs*. Dr. Gorrie is an officer of the Forest Service of India. He toured the United States specifically for the study of correlation between erosion damage and grazing in forest lands, a problem acute in India. He finds a close similarity between India and the United States "in that a small proportion of each has been managed more or less efficiently by their respective forest services for the dual uses of forestry and grazing, while the bulk of the remaining public

grazing land has suffered so badly from uncontrolled overgrazing as to have deteriorated in value and productive capacity. . . . The one point in live-stock management on which all in the United States are agreed is the calamitous consequences of free grazing on their public domain, which is an exact parallel of the Indian village grazing system." Among Indian illustrations cited is the striking case of overgrazing in the dry foothills of the Punjab Siwaliks. Dr. Gorrie also made observations on erosion on farm land for application to the problem of shifting agriculture in India. In this connection he cites methods used in Burma whereby some tree crop is restored to abandoned cultivated land.

"Le Sahara" in Translation

E. F. Gautier. **Sahara: The Great Desert.** Translated by Dorothy Ford Mayhew. xvii and 264 pp.; maps, diagrs., ills., bibliogrs., index. Columbia University Press, New York, 1935. $3.75. 9½ x 6½ inches.

In his introduction to this translation of "Le Sahara" Professor Douglas Johnson narrates the following anecdote: "Seated in his laboratory at the University of Algiers, I asked Professor Gautier to tell me something of his methods of exploration in the greatest of the world's arid regions. 'Oh, it is very simple,' he replied. 'You just get some camels and some food, and go.' " And Gautier has been "going" many years—to our profitable acquaintance with his desert. The anecdote illustrates the simplicity and directness of Gautier's method of work that find a reflection in the delightful clarity of his writings. The classic "Le Sahara" has appeared in two French editions (for an appreciation of the first edition see *Geogr. Rev.*, Vol. 15, 1925, pp. 92–105), and an English translation has been overdue. We are grateful to the translator for a rendering that preserves much of the quality of the original and to the publishers for putting out the volume in attractive guise. Some changes have been made in arrangement, and there is some new material, including results of Professor Gautier's latest expeditions, for instance, the excavation of the tomb of Tin Hinan (cf. E. F. Gautier: The Monument of Tin Hinan in the Ahaggar, *Geogr. Rev.*, Vol. 24, 1934, pp. 439–443) and the discovery of rock paintings and engravings in Tassili (*idem:* The Ancestors of the Tuarega, *ibid.*, Vol. 25, 1935, pp. 12–20).

A Geographic Education Series

George J. Miller, edit. **Human Geography Studies: The United States.** 258 pp.; maps, diagrs., ills. (Geographic Education Series.) McKnight & McKnight, Bloomington, Ill., 1935. $2.00. 9½ x 6½ inches.

The National Council of Geography Teachers has had the happy idea of reproducing in unit form some of the contributions that have appeared in recent years in its *Journal*. The current volume is the second; the first, entitled "Geography: How to Teach It," appeared the previous year. The studies are samples, illustrative of a wide variety of conditions under which men live and work in the United States—from the sod house to the city of Los Angeles; from life in a Blue Ridge hollow to the Columbia-basin project.